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ABSTRACT

Abstracts of papers presented to the 44th Annual Meeting of the National Association for Research in Science Teaching are arranged according to the topic of the session at which they were presented. Separate sessions were devoted to elementary, secondary, junior high school, and college and university science teaching, with papers on evaluation, teaching techniques, teacher and student behavior, curriculum, and attitudes being presented at each level. Papers were also presented on science teacher education at pre- and in-service levels, on learning and testing, and on environmental education and educational technology. Abstracts of addresses to general sessions, on educational research, the future of NARST, science education curriculum development, and guidelines for science and mathematics teacher education are also included. (AL)

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NATIONAL ASSOCIATION
FOR RESEARCH IN SCIENCE TEACHING

44th ANNUAL MEETING

ABSTRACTS OF PRESENTED PAPERS

Sheraton Hotel
Silver Spring, Maryland
March 23-25, 1971

PREFACE

The ERIC Information Analysis Center for Science and Mathematics has cooperated with the National Association for Research in Science Teaching to provide abstracts of most of the papers presented at the annual conference in Silver Spring, Maryland, March 23-25, 1971.

All persons who had papers or symposia accepted were invited to submit abstracts for inclusion in this publication. Some editing was done by the ERIC Staff to provide a general format for the abstracts. Special recognition should be given to Dr. Frank X. Sutman who organized the program and obtained most of the abstracts and to Dr. Patricia Blosser for extensive assistance in preparing the abstracts. The document was typed and compiled by Mrs. Maxine Weingarth, Mrs. Cheryl Brosey, Mrs. Cassandra Balthaser, and Miss Susan Hedger.

Many of the papers will be published in journals or be made available through the ERIC system. These will be announced through Research in Education and other publications of the ERIC system.

February, 1971

Robert W. Howe
Director
ERIC Information Analysis
Center for Science and
Mathematics Education

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Concurrent Sessions I

Session Ia - College and University Science

Chairman: Robert Bridgham, Stanford University, Stanford, California

1. "Types of Questions Asked by College Science Instructors," George Moriber, Brooklyn College, Brooklyn, New York.
2. "Cognitive Style, Attitude Toward Science, and Sex on Success with Programmed Instruction on Kinetic-Theory," Frederick K. Ault, Ball State University, Muncie, Indiana, and Hans O. Andersen, Indiana University, Bloomington, Indiana.
3. "The Effectiveness of a Cybernetic Model as an Advance Organizer in Teaching Physiological Regulation," Kathryn E. Malone, Westchester Community College, Valhalla, New York.
4. "An Application of Stake's Evaluation Model: Report of the Physics Education Evaluation Project (PEEP) of the University of British Columbia," Philip G. Bashook and Walter B. Boldt, University of British Columbia, Vancouver, British Columbia.
5. "Development and Use of a Laboratory Block Dealing with the Lysis of Algal Cell Walls by Soil Microorganisms," Myrna C. Thomas and Frank X. Sutman, Temple University, Philadelphia, Pennsylvania.
6. "The Effects of Programmed Instruction, Computer-Assisted Performance Problems and Open-Ended Experiments on Student Attitude and Problem-Solving Ability in Physical Chemistry Laboratory," Stephen F. Godomsky, University of Maine, Farmington, Maine.

TYPES OF QUESTIONS ASKED BY COLLEGE SCIENCE INSTRUCTORS

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Brooklyn, New York

Mastery of the art of questioning is considered by most educators to be essential for good teaching. Prospective teachers, below the college level, study techniques of questioning in methods of teaching courses. However, college instructors generally do not receive formal training in methods of teaching and must develop their own style. Often this must be accomplished with little or no assistance.

In an effort to determine the types of questions asked by college instructors, an investigation was undertaken with four college laboratory instructors. These teachers were teaching the second half of a one-year physical science course for non-science students. None of the college instructors had ever been enrolled in a teacher training program.

The instructors were observed for a period of five consecutive weeks and all the lessons were taped. Following each observation an intensive one-hour conference was held. During these conferences, techniques of questioning and the use of different types of questions were discussed.

Teacher questions were categorized using the classification system developed by Sanders.* In this taxonomy, types of questions are classified as belonging to one of seven types. The categories are sequential--the higher level question categories include the lower level categories. In sequential ascending order, the categories are memory, translation, interpretation, application, analysis, synthesis, and evaluation.

Each tape was carefully studied and the questions asked by the instructors were placed in the appropriate category. This procedure was followed throughout the experiment. One-hour conferences were held after each lesson.

The results of the study indicated that the teachers consistently asked lower level questions; the overwhelming number of the questions being in the memory or translation category.

After the experimental period ended, informal discussions were held with each instructor. At the conferences the unexpected results were discussed. The teachers were asked to offer possible explanations for the lack of change in their styles of teaching. Their comments indicated that they did not believe that thought provoking questions were necessary. Further, they expressed the view that questioning slows down the lesson, consumes too much time, and is not superior to lecturing. In sum, they believed that their students were learning via the lecture method.

---

* Sanders, N. M., Classroom Questions - What Kinds? (New York: Harper and Row 1966).

The study has educational importance in that a large portion of our potential elementary school teachers probably are taught science by the lecture method. This could result in their adopting this style of teaching as their primary mode of communicating science to their students.

COGNITIVE STYLE, ATTITUDE TOWARD SCIENCE, AND SEX ON SUCCESS WITH PROGRAMMED INSTRUCTION ON KINETIC-THEORY

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Muncie, Indiana

and

Hans O. Andersen
Indiana University
Bloomington, Indiana

The purposes of this study were to determine the effect of: (1) the student's initial attitude toward science and science instruction, (2) the sex of the individual, and (3) the education set of the individual on success with programmed instruction materials on the basic gas laws.

A control group and two experimental groups consisting of 32 students each were randomly selected from a general education chemistry enrollment at Ball State University during the spring quarter, 1970.

A linear programmed instruction sequence and a criterion test were designed and constructed for general education chemistry students on the basis of performance objectives prepared for the basic gas laws. Also, an attitude inventory designed to measure the initial attitude of the student toward science instruction was designed and constructed. The content validity of each instrument was determined by educators.

Laurence Siegel's test on cognitive style was used to establish the cognitive style of each individual.

The control group was used to determine the retest reliability of the criterion test and the attitude inventory and to determine the treatment effect of the programmed instrument. The group received no instruction on kinetic theory.

One experimental group was administered the criterion test as a pretest, the Program on Gases, and the criterion test as a posttest; the other experimental group was administered the Program on Gases and the criterion test as a posttest. Both groups were administered the attitude inventory and the test on cognitive style.

Several one-way analyses of variance were employed to determine the significance of effects attributable to: (1) attitude of the individual toward science and science instruction on achievement, (2) sex on achievement, (3) cognitive style on achievement, and (4) treatment effects as measured by the criterion test. A three-way split of each group population was used to level on attitude and cognitive style.

A significant difference ($p < 0.001$) attributed to the Program on Gases treatment was found between the control group mean and both experimental group means on the criterion test. No significant difference existed between each experimental group mean indicating that the pretest did not produce a significant effect on the criterion test scores.

No significant difference attributable to the effect of cognitive style or sex of the individual on the criterion test was found. It was concluded that position on the educational set continuum and the sex of the individual did not influence success on the criterion test.

A possible trend favoring the individual with a high positive attitude may exist between the criterion test scores and attitude ($p < 0.20$). Also, a trend favoring the male population may exist between sex and the attitude of the individual ($p < 0.10$).

The research indicates that: (1) programmed instruction can be used to teach basic gas laws to general education chemistry students, (2) cognitive style does not influence achievement resulting from the instruction presented in this study, (3) the attitude of the individual may influence success on the criterion test, and (4) a possible trend may exist between the sex and the attitude of the individual toward science and science instruction.

As a result of this study, research should be conducted to determine the following: (1) the role of educational set in the development of instructional materials, (2) the age of the individual at which educational set is established, and (3) the type of curve existing between attitude of the individual toward science and science instruction and age.

THE EFFECTIVENESS OF A CYBERNETIC MODEL AS AN ADVANCE ORGANIZER IN TEACHING PHYSIOLOGICAL REGULATION

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Valhalla, New York

Two separate studies were conducted to test the following hypotheses: (a) knowledge acquisition of students receiving a cybernetic model advance organizer will be higher than that of students receiving a historical introduction prior to a learning task on physiological regulation; and (b) knowledge retention of students receiving a cybernetic model advance organizer will be higher than that of students receiving a historical introduction prior to a learning task on physiological regulation.

The cybernetic model formally conceptualized a control system in terms of its component parts and mode of operation. Since the model and the accompanying explanation provided a general framework of control systems, it was hypothesized that the model would act as an advance organizer for teaching physiological regulation. The theory upon which these studies were based is derived from Ausubel's theory of cognitive subsumption.

The sample populations consisted of community college students enrolled in the introductory biology course. The Ss were randomly assigned to either the advance organizer group or historical introduction group. All materials were written, therefore, both treatments were administered simultaneously. The criterion measure was a multiple choice test developed by the author.

Students were directed to read the introductory passage twice and then proceed to the learning passage which they read twice. When they finished reading the materials they were given the multiple choice test based on the four regulatory systems presented in the learning passage. In the first study the subjects were retested after three weeks while in the second study they were retested after one week.

Two-way analysis of variance showed no significant difference between treatment groups or between males and females, and no interactive effects between treatment and sex.

The results of this study do not support the premise that the use of appropriate advance organizers can facilitate learning and retention of specific information. This study, in addition to others, implies that while the use of advance organizers might be quite appropriate in certain educational situations, more information is needed before its wide acceptance in all settings can be advocated. In light of the empirical findings, it is necessary to consider the possibility that the theory upon which these studies were based is weak and deserves a re-evaluation. Indeed, much remains to be learned about advance organizers and cognitive subsumption. The application of this learning theory to science education provides an area for critical inquiry.

AN APPLICATION OF STAKE'S EVALUATION MODEL:
REPORT OF THE PHYSICS EDUCATION EVALUATION PROJECT (PEEP) OF THE UNIVERSITY OF BRITISH COLUMBIA

Philip G. Bashook
and
Walter B. Boldt
University of British Columbia
Vancouver, British Columbia

The problem of major concern to the Project is the improvement of teaching and learning physics at the college level. The present paper deals with a study of specific problems having to do with formative and summative course evaluation. In particular, the paper deals with the development of instruments and procedures for gathering data on objectives, values, priorities, and standards, for a first year college course in physics. This aspect of dealing with the problem is important in that it enables replication of observations made on a course, thereby providing a basis for deciding what confidence to place on evaluation data gathered.

Stake (1967)*, suggested a number of descriptive categories to be attended to in curriculum evaluation. Intended and observed course antecedents, transactions, and outcomes constitute one set of categories. Standards and judgments relevent to antecedents, transactions, and outcomes, and the course rationale constitute the other sets of descriptive categories. Congruence and contingency are viewed as criteria which should control an over-all appraisal.

Project PEEP (Physics Education Evaluation Project: Interim Report, 1970)**, is attempting to use Stake's categories in formulating an evaluative description of physics teaching and learning at the college level. Instruments and procedures have been developed by the Project for this purpose and are described in the paper.

The first stage of the study, development of instruments and procedures, was carried forward in two phases. Phase I was concerned with establishing the course rationale, and the development of observational tools and procedures for evaluation of lectures, tutorials, and laboratory sessions. Essential to this phase of the study was the close cooperation between the evaluator and his clients--students, instructors, and others concerned with the course. Phase I was initiated in May, 1969, after lengthy discussions with the major instructor on problems of educational evaluation, and was completed in December, 1969.

---

* Stake, Robert E. "Countenance of Educational Evaluation." Teachers College Record. 68: 523-40; 1967.

**Westphal, W. and Boldt, W. Evaluation of Physics at the First Year University Level: an Interim Report. Vancouver: Physics Department, University of British Columbia, 1970. (Photocopy.)

Phase II of the study, testing of methods and tools, began in January, 1970, and was completed in May, 1970. Analysis of the results of this work was undertaken during the Summer of 1970. Close cooperation between evaluator and client was maintained throughout this phase of the study in order to insure a thorough understanding of the usefulness and limitations of the procedures and instruments developed and to enhance the possibility of self-generating and sustained effort in the Department toward course improvement.

Figure I shows schematically some of the instruments and procedures developed for an evaluation of a single lecture using Stake's categories.

In addition, a Personal Data Questionnaire, Cognitive Tests, a semantic differential type Affective Response Instrument, Pre- and Post-Tutorial Analysis Questionnaire, and a Tutorial Interaction Analysis Method, were developed by the Project for individual session and over-all course evaluation.

Among the procedures developed for evaluation was a method of analyzing the logic of teaching strategies used in teaching concepts and a method of determining the compatibility of logical skills required in the course and the skills available to students. Multi-variate techniques were used to study the nature of certain *a priori* determined groups of interest taking the course. Multidimensional scaling techniques were utilized for establishing the standards, priorities, and values of those concerned with the course.

The evaluator may lessen the arbitrariness of judging and decision-making by introducing data-gathering instruments and procedures already developed by other social scientists. Many of their methods can be used to measure the judgments that shape an educational program.

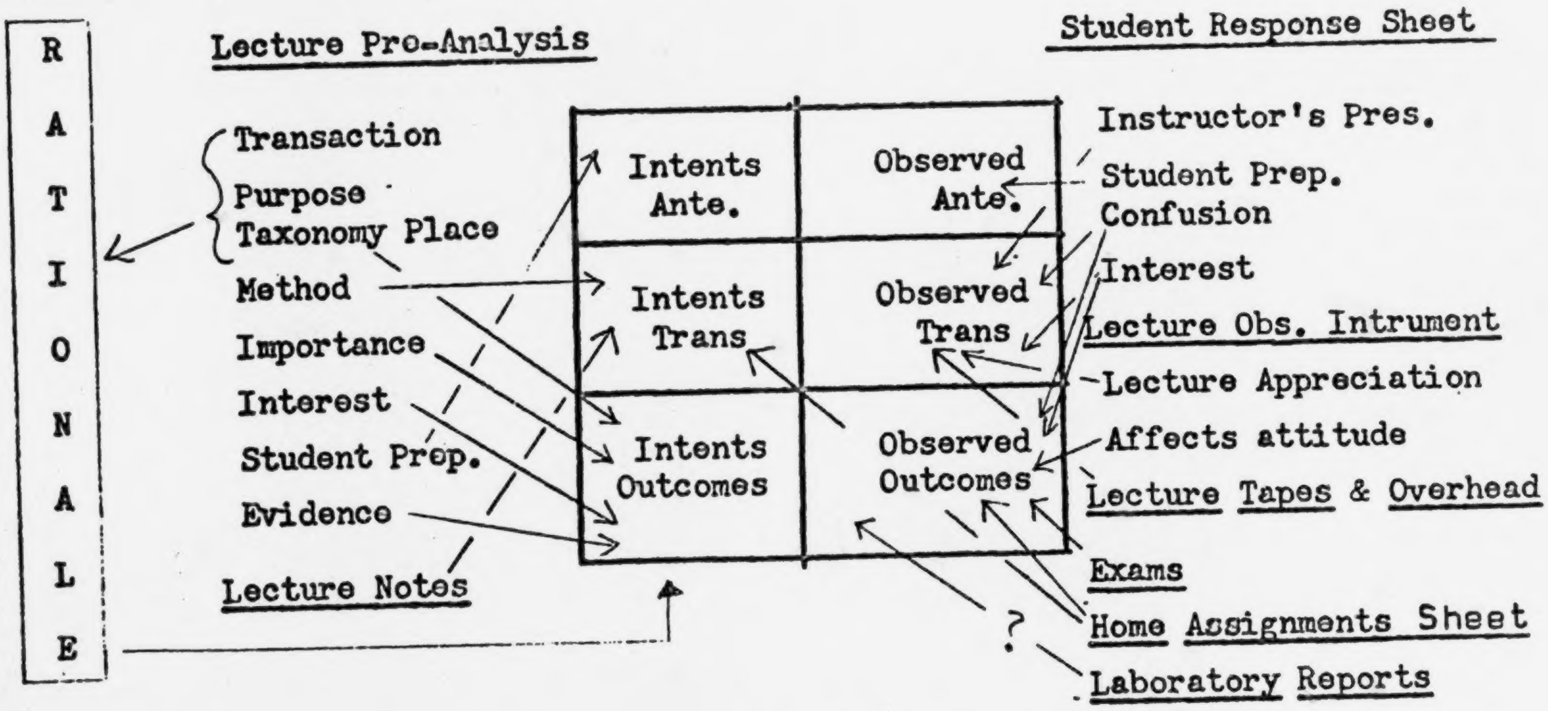
RATIONALE
Lecture Pre-Analysis
Transaction
Purpose
Taxonomy Place
Method
Importance
Interest
Student Prep.
Evidence
Lecture Notes
Intents Ante.
Intents Trans
Intents Outcomes
Observed Ante.
Observed Trans
Observed Outcomes
Student Response Sheet
Instructor's Pres.
Student Prep.
Confusion
Interest
Lecture Obs. Intrument
Lecture Appreciation
Affects attitude
Lecture Tapes & Overhead
Exams
Home Assignments Sheet
?
Laboratory Reports

Figure I

Instruments and Procedures for Evaluating

a Lecture Using Stake's Descriptive

Categories

DEVELOPMENT AND USE OF A LABORATORY BLOCK DEALING WITH THE LYSIS OF ALGAL CELL WALLS BY SOIL MICROORGANISMS

Myrna C. Thomas
and
Frank X. Sutman
Temple University
Philadelphia, Pennsylvania

Research involving the production, isolation, and characterization of enzymes causing the lysis of Chlorella cell walls led to the development of an open-ended laboratory block designed for use in introductory college biology. The Laboratory Block is a problem-centered activity.

Like the BSCS laboratory blocks, the investigator's Laboratory Block asks the student to work, act, and think creatively like a scientist. Emphasis is placed on science as a never-ending, self-correcting process. In addition to these qualities, the author's Laboratory Block gives each student the opportunity to design his own experiment.

The Laboratory Block is based upon that phase of the investigator's graduate research which involved the isolation of a soil microorganism capable of utilizing Chlorella cell walls as its sole carbon source. With the termination of Part I of the Laboratory Block, there is a discussion of possible avenues for further research and a list of readings for the student. Each student is free to choose between three alternatives: (1) to continue the investigation of his microorganism with an experiment of his own design, (2) to continue the investigation with the experiment outlined within the Laboratory Block, or (3) to discontinue work on the project and to resume the usual laboratory activities.

The Laboratory Block was subjected to a pilot trial in a laboratory section of students enrolled in a non-majors biology course at Trenton State College. Questionnaires were given prior to and after participation in the Laboratory Block and were used to determine student reactions.

The Laboratory Block was well-received by the students with 61 percent indicating they enjoyed it more than their usual biology exercises. Seventy-eight percent of those involved in the pilot study indicated that they were more familiar with research processes from participating in the Laboratory Block activities. Based on questionnaires given prior to the inception of the pilot study, it was predicted that 30 percent of the group would choose to continue with further experiments; however, 61 percent chose to continue.

The Laboratory Block involves a problem-centered approach to biology and chemistry, integrating the various fields, rather than the more traditional one field content-oriented approach.

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THE EFFECTS OF PROGRAMMED INSTRUCTION, COMPUTER-ASSISTED PERFORMANCE PROBLEMS AND OPEN-ENDED EXPERIMENTS ON STUDENT ATTITUDE AND PROBLEM-SOLVING ABILITY IN PHYSICAL CHEMISTRY LABORATORY

Stephen F. Godomsky
University of Maine
Farmington, Maine

The purposes of this study were to determine the effectiveness of: (1) experiments without explicit directions; (2) programming of prerequisite capabilities for each of four basic experiments; and (3) using performance problems programmed for computer evaluation.

Two professors and three teaching assistants were assigned to the treatment group. Both professors taught all students. One assistant helped students in the laboratory, a second was responsible for evaluating laboratory reports, and the third ensured over-all coordination of the teaching assistants.

This study involved one treatment group of 14 and three control groups--A, B_1, and B_2--of 28, 5, and 5, respectively. The group of 28 did the basic experiments during the spring of 1969, and their scores were compared with the treatment group using chi-square tests of significance. Control group B_1 was assigned problem 2, and control group B_2 was assigned problem 1 as posttest measures. They took problem 1 as an introductory measure. The treatment group was given four posttest measures which resulted in five scores.

A one-way analysis of variance was used to determine homogeneity of groups on the covariate mean of chemistry GPA. The slopes of the regression lines for each group on the posttest measures were also determined by a one-way analysis of covariance, and the groups were from the same population. Additional analyses conducted were: (1) two one-way analyses of covariance comparing the experimental group with control groups B_1 on problem 2 and B_2 on problem 1; (2) five one-way analyses of covariance comparing the students in the experimental group who had completed the physical chemistry lecture class with those who had not on all posttest measures; and (3) a qualitative evaluation of attitudes called course evaluation instrument.

There were significant effects on student scores on posttest problem 1 ($p < .01$) and problem 2 ($p < .001$) attributable to the treatment. It was concluded that the problem-solving ability in physical chemistry is greater among students enrolled in the laboratory course. There were significant treatment effects on student success on four basic experiments, the gas thermometer ($p < .001$), vapor pressure of liquids ($p < .001$), triple point of ammonia ($p < .001$) and gas phase equilibrium ($p < .05$) experiments. It was concluded that the greater success of the experimental group could be attributed to the conversational mode pre-lab programmed tests. Five computer programs were designed to evaluate student experimental procedures and facilitate instruction by (1) providing a more complete objective evaluation and (2) significantly reducing faculty time for this activity.

The student results on performance tests used in this study indicate that (1) the designed laboratory instruction does increase the student's problem-solving ability in physical chemistry if the experiments are genuine problems without explicit directions.

The following recommendations are based on this study: (1) the instructional technique should be developed for use in freshman chemistry laboratory instructions; (2) evaluation of instruction should include questionnaires similar to the course evaluation instrument; and (3) further research should focus on laboratory reports and evaluation of laboratory outcomes using performance tests.

Session Ib - Secondary Teacher Education--Specialized Training and Teaching Strategies

Chairman: Eugene Lee, Emory University, Atlanta, Georgia

1. "An Identification of Technical Skills of Science Supervisors and The Development of a Science Supervisors' Technical Skills Inventory," Lewin A. Wheat, Maryland State Department of Education, Baltimore, Maryland, and J. David Lockard, University of Maryland, College Park, Maryland.
2. "Exploratory Investigations with an Experimental Test on Methods and Procedures of Science," Kenneth F. Jerkins, Morgan State College, Baltimore, Maryland.
3. "Learner Reaction to 'The Inquiry Method'," Donald J. Schmidt and Harold Desmond, Jr., Fitchburg State College, Fitchburg, Massachusetts.
4. "Effects of Instructor and Student Directed Feedback in Individualized Instruction," James R. Okey, Indiana University, Bloomington, Indiana, and Lorraine B. Foust, University of California, Santa Barbara, California.
5. "The Relationship Between a Verbal Measure of Predictive Ability and Performance on Selected Science Process Tasks," Van E. Neie, Purdue University, Lafayette, Indiana.
6. "An Investigation of the Cognitive and Affective Verbal Behavior of Selected Groups of Physical Science Teachers," Robert J. Miller, Eastern Kentucky University, Richmond, Kentucky.

AN IDENTIFICATION OF TECHNICAL SKILLS OF SCIENCE SUPERVISORS AND THE DEVELOPMENT OF A SCIENCE SUPERVISORS' TECHNICAL SKILLS INVENTORY

Lewin A. Wheat
Maryland State Department of Education
Baltimore, Maryland

and

J. David Lockard
University of Maryland
College Park, Maryland

The problem of this study was to identify technical skills of science supervisors and to develop a science supervisors' technical skills inventory.

A review of the literature provided the rationale for the study and served to identify the responsibilities, tasks, and activities of science supervisors. Technical skills were identified within eight major task areas: leadership, curriculum development, inservice education, science facilities, equipment and materials, science teaching methods, self-growth, and public relations. From the activities in these task areas 245 specific technical skills were written. These skills were subjected to a pilot study with experienced science supervisors in a National Science Foundation academic year institute. On the basis of this experience a revised list of technical skills was produced and was submitted to a national jury comprised of four panels: state science supervisors, local science supervisors, science educators, and directors of National Science Foundation institutes for science supervisors. A total of 48,861 bits of information from 183 members of the jury were tabulated and summarized. Skills approved by 75 percent or more of the jury were included in a "Science Supervisors' Technical Skills Inventory." The inventory was used with two National Science Foundation academic year institutes for science supervisors to determine in which of the skills these supervisors needed the most help and in which they felt most competent.

Findings from the study resulted in a list of 180 technical skills of science supervisors which received the endorsement of 75 percent or more of the national jury. Jury responses placed a high priority on skills oriented toward the overall supervisory functions and a lower priority on those skills closer to the teaching process. The national jury provided greatest support for technical skills in the task area of self-growth, science facilities, and inservice education. Least support was given to skills in the task area of equipment and materials. Experienced science supervisors in the academic year institutes indicated that they did not possess many of the technical skills agreed upon as technical skills needed by science supervisors. The "Science Supervisors' Technical Skills Inventory" served as an instrument to identify skills possessed and skills in which help was needed.

This study is viewed as an exploratory probe into the concept and the nature of technical skills in science supervision. An initial list of technical skills has been provided from which skills may be discarded and to which skills may be added. Technical skills have been identified for which behavioral objectives and performance criteria can be developed as a means of preservice and inservice training. The "Science Supervisors' Technical Skills Inventory" can be used in preservice and inservice education classes, workshops, and institutes for science supervisors to identify the technical skills possessed and the technical skills in which help is needed. The inventory can be used by local science supervisors for self-evaluation.

More detailed and quantitative studies are necessary to explore this field and consider further development, revision, replacement with something better, or rejection of the concept of technical skills in science supervision.

EXPLORATORY INVESTIGATIONS WITH AN EXPERIMENTAL TEST ON METHODS AND PROCEDURES OF SCIENCE

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Emphasis upon "inquiry," or "methods and procedures of science," has been one of the dominant themes in science education K-16 during most of the last decade. Virtually none of the new science curricula K-16 advocate "read-about talk-about" approaches to science over and above those strategies which include and emphasize knowing about and understanding the "methods and procedures of science." At Morgan State College all general education science classes are scheduled for weekly two-hour laboratory periods purportedly designed to emphasize "inquiry" and the "methods and procedures of science." Are there any tests in print that can be used to measure achievement gain relative to knowledge about understanding of "methods and procedures of science" at the collegiate level?

Woodburn has developed a Methods and Procedures of Science Test. This test was not developed specifically for use at the collegiate level. The Woodburn test consists of fifty (50) five-alternative multiple choice items. The items are organized into three subsets each consisting of one or more item clusters. Part I, "The Meaning of Words Used in the Pursuit of Science," is comprised of items 1-28. Part II, "Recognizing the Plan or Design of Experiments," includes items 29-34. Part III, "Drawing Conclusions from Experiments," consists of items 35-50 which are organized into three item-clusters based on growth of adventitious roots, absorption of water by seeds, and irradication of a detrimental insect.

The exploratory investigations reported in this paper were undertaken for the following purposes: (1) to obtain normative data needed to interpret Methods and Procedures of Science Test scores; and (2) to determine the feasibility of using the Methods and Procedures of Science Test to measure achievement gain in general education biological science classes at the collegiate level.

During the period September, 1968, to November, 1969, the Methods and Procedures of Science Test was administered to several selected classes at Morgan State College (Baltimore). Subjects tested included undergraduate non-science majors, undergraduate biology majors, prospective science teachers, graduate in-service elementary teachers, and graduate in-service secondary school science teachers.

Methods and Procedures of Science Test data were organized and analyzed in order to answer specific questions about: (1) item statistics; (2) average overall test performance; (3) average subtest performance; and (4) the effect of pretesting where the test had been used with various collegiate academic groups.

Item statistics and subtest scores indicate that some test items should be revised. The average test score obtained by each academic group was lower than anticipated. Measures of test reliability determined by KR-20 and KR-21 ranged from 0.84 and 0.78 for science teachers enrolled in graduate in-service institute courses to 0.55 and 0.43 for a group of freshmen non-science majors. Mean scores and corresponding standard deviations for the aforementioned academic groups were 28.4 and 7.3 for the in-service teachers and 21.9 and 4.8 for the freshman non-science majors. The effect of pretesting was not significant.

Data summarized in this report indicate that the 1967 version of the Methods and Procedures of Science Test should be revised considerably and lengthened. Additional effort should be made to ascertain the construct validity of the test. A revised and improved form of the test should be used extensively to sensitize and stimulate emphasis upon "inquiry" or "methods and procedures of science" at the collegiate level. If "what is past is prologue," science educators should expect mounting waves of reaction against expenditures for laboratory activities in general education science courses. Valid and reliable test data would help those who will have to meet "accountability" criteria with respect to the feasibility of providing laboratory activities for non-science majors at the collegiate level.

LEARNER REACTION TO "THE INQUIRY METHOD"

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and
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A survey of Science Education literature of the past ten years will reveal volumes about the general topic of Inquiry or Discovery teaching and/or learning. Very seldom do the investigators ask the learner how he feels about the various learning and teaching methods. This study was designed to obtain feedback from students with regard to inquiry or discovery learning situations.

A questionnaire about teaching methods was developed by the authors and was administered to students from grades seven to twelve. The various items were designed to obtain student reactions to inquiry or discovery teaching/learning experiences.

The results indicate that by no means do all students in any given class enjoy or want to be involved in inquiry or discovery type learning experiences. Furthermore, the data seem to indicate that some students simply do not recognize an "inquiry" method of teaching when it is in use.

The results of this study indicate that the average classroom teacher may very well be faced with the task of teaching some students who enjoy, like, and want an inquiry/discovery type of class while in the same group other students simply do not have a positive attitude toward this kind of instruction. This seems to support the idea of individualized instruction. It also seems to support the use of a wide variety of teaching methods as opposed to the idea of developing one good method that may "work" for any given teacher.

EFFECTS OF INSTRUCTOR AND STUDENT DIRECTED FEEDBACK IN INDIVIDUALIZED INSTRUCTION

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and

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One important way in which learners differ is in what they are able to do. Efforts to accommodate differences in learners have led to the development of programs for individualizing instruction. A typical procedure in such a program is first to measure what the learner can do and cannot do (diagnosis) and then to select an appropriate task for further study (prescription).

This study was conducted to investigate the effectiveness of a program designed to teach selected science process skills. The specific question was, "Can the effectiveness of an individualized instruction program be increased with frequent diagnostic tests followed by appropriate remedial practice?"

A sample of 70 pre-service elementary school teachers was assigned to three treatment groups and given the task of constructing and interpreting graphs. A total of ten subordinate tasks thought to be necessary for learning the final task was derived and arranged in a hierarchical sequence.

One treatment group received instruction on the tasks using a tape-slide program during which learners made frequent responses and received feedback. After instruction on each task a diagnostic test was individually administered and remedial instruction was provided as needed. Members of the second group received the same tape-slide program but no diagnostic tests were administered nor remedial instruction provided. The third group received no instruction.

Each of the two groups receiving instruction performed better on the final task than the control group. Contrary to expectations, however, the group receiving individualized diagnosis and prescription did not perform significantly better than the other experimental group. In addition, fewer than half the learners in each of the three groups were able to perform the final task.

Because of the failure of the diagnosis and prescription scheme, a new approach to the problem was tried. Instead of having the instructor administer diagnostic tests and prescribe additional practice tasks, it was decided to give the learner this responsibility. Tests, answer sheets, and programmed exercises were prepared so that learners could operate a program of self-evaluation and remedial instruction.

The new program of student-directed diagnosis and prescription was tried out in a subsequent experiment. The same tape-slide program was used but now the students were stopped at intervals and provided with tests, answers, and practice exercises. Each student administered his own exam, corrected it, and directed himself to remedial exercises as he saw fit. Following instruction using this revised approach, in excess of 80 percent of the learners could perform the final task.

Although the results of this last experiment are encouraging, they are extremely tentative because of the size and method of selection of the experimental group. An investigation is presently underway in which a student-directed diagnosis and prescription scheme is being subjected to a more rigorous test.

Guidance for developers of instruction can be provided if it can be demonstrated that achievement (and perhaps attitude) is affected by the procedures used to locate and remedy student errors.

THE RELATIONSHIP BETWEEN A VERBAL MEASURE OF PREDICTIVE ABILITY AND PERFORMANCE ON SELECTED SCIENCE PROCESS TASKS

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The investigation was designed to determine the relationship between performance on selected science process tasks and an ability to comprehend, through contextual clues, the operational meaning of verbal directions specific to those tasks. The comprehension ability was assessed by means of the cloze procedure, a technique whereby Ss attempt to restore whole words deleted from printed materials. Since successful performance on a cloze test is indicative of an ability to predict a received verbal message, the cloze score can be thought of as a verbal measure of predictive ability, referred to in this study as "verbal predictive ability."

The two main questions asked in this study were:

1. Is the cloze performance a better predictor of performance on science process tasks than is a standardized test of verbal ability?

2. Is verbal predictive ability a relevant ability for all tasks used in the study?

Forty-two prospective elementary school teachers were given twenty-four tasks from the "Predicting" hierarchy of the AAAS Process Instrument. The task directions were presented in printed form, every fifth word deleted. The scores resulting from replacing the missing words were correlated with the total process task score and scores on two external measures -- a standardized verbal ability test and a science vocabulary test.

The criterion scores correlated highest with the cloze scores (.56), second highest with the verbal test scores (.43), and lowest with the vocabulary test scores (.29). Although the first two coefficients were significant at the .01 level, their difference was not significant. A multiple correlation of .58 was obtained between the criterion scores and the three predictor variables. The largest contributor to the accountable variance was the cloze score, with only a small additional contribution from the remaining variables. The correlation coefficients were corrected for attenuation in the criterion scores, but no statistical test known to the writer enabled comparisons to be made between these corrected coefficients; however, they provided additional information concerning the size of the correlations to be expected with more reliable instruments.

Point-biserial _r_'s were obtained between the total cloze score and the pass-fail achievement of each task. Six of the coefficients were found to be significant beyond the .05 level, although no hierarchical pattern was evident.

The strong correlation between performance on the process tasks and performance on the cloze test suggests that Ss who are able to predict the verbal message associated with given tasks are better able to perform these tasks. This ability is different from that usually classified as verbal ability in the sense that it mediates the transition from specific verbal statements. The results further indicate that this ability is more than simply possessing an extensive science vocabulary.

The results of the study have implications for the design of instructional materials used in the teaching of science process skills. As an in-context measure, the cloze procedure assesses the verbal comprehension of the learner while simultaneously providing information about the communicative effectiveness of the printed materials.

AN INVESTIGATION OF THE COGNITIVE AND AFFECTIVE VERBAL BEHAVIOR OF SELECTED GROUPS OF PHYSICAL SCIENCE TEACHERS

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The purposes of this study were: (1) to explore selected verbal teaching strategies and tactics used by two groups of ninth grade physical science teachers and (2) to determine the effects of a laboratory centered training program on the verbal behavior of the participants.

The Science Classroom Interaction Instrument (SCII) developed in the study measured verbal behavior pertaining to both the social-emotional climate of the classroom and cognitive teaching tactics.

Two groups of ninth grade physical science teachers, each consisting of eleven teachers, were selected from the Austin, Texas, public school system for use in the study.

The treatment for one of the teacher groups consisted of participation in a training program sponsored by the National Science Foundation, that included two phases: (1) a summer institute and (2) inservice training during the following academic year. A significant part of the treatment involved training in the control of classroom verbal behavior in the science classroom. The second teacher group received no special treatment.

A total of 212 separate audio recordings obtained in classrooms were accumulated during a calendar year. The recordings were then analyzed by two coders using the SCII. The Scott Reliability Coefficient for the twenty five category SCII was established as being 0.735.

The nonparametric Mann-Whitney U Test was used to determine statistically significant differences in verbal behavior between the two teacher groups and also within the teacher groups. Two hundred ninty-nine statistical comparisons were made during the study with the results reported at the .05 and .02 levels of confidence.

The SCII was able to detect statistically significant differences in changes of six categories of verbal behavior within the treatment group when pre-treatment behavior was compared to post-treatment behavior following the summer training phase.

When the treatment group of teachers were compared to the nontreatment group of teachers, they: accepted feelings more, gave praise or encouragement more, accepted or used student responses more, asked more science questions at higher cognitive levels, used criticism or rejection of students' ideas less, and initiated more student responses.

Verbal behavior of the nontreatment group remained relatively static through an academic year. Verbalizations dealing with philosophical areas of science teaching were found to be used infrequently. Sustained changes in verbal behavior exhibited by the treatment group during the academic year were: more use of questions which integrated science and technology, more high cognitive level questioning, the occurrence of more student responses initiated by the teacher, and more use of silence for contemplation.

The results of this study suggest a possible need and usefulness of retraining teachers in order to achieve a compatibility between their verbal behavior and modern aspects of both affective and cognitive instruction in science education.

Session Ic - Junior High Science Including the Effects of the Objectives
and Inquiry

Chairman: Joseph S. Schmuckler, Temple University, Philadelphia, Pennsylvania

1. "Effectiveness of an Inquiry Approach to Environmental Study for Seventh Grade Students with Learning Problems," Joy S. Lindbeck, The University of Akron, Akron, Ohio.
2. "The Development and Evaluation of Physical Science Curriculum Materials Designed to Improve the Attitudes of the Secondary School Slow Learner," James L. Milson, The University of Texas at El Paso, El Paso, Texas.
3. "The Effects of Performance Objectives on the Achievement Level of Selected Eighth-Grade Science Pupils in Four Predominantly Black Inner City Schools," Napoleon Bryant, Jr., Xavier University, Cincinnati, Ohio.
4. "Learning Achievement and the Efficiency of Learning the Concept of Vector Addition at Three Different Grade Levels," Allan Gubrud, Lane Community College, Eugene, Oregon, and Joseph Novak, Cornell University, Ithaca, New York.
5. "Concept Formation by Junior High School Students Using Inductive Methods," R. Keith Hanson, Illinois State University, Normal, Illinois.

EFFECTIVENESS OF AN INQUIRY APPROACH TO ENVIRONMENTAL STUDY FOR SEVENTH GRADE STUDENTS WITH LEARNING PROBLEMS

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The research reported in this paper was designed to evaluate the effectiveness of curriculum materials pertaining to the environment and presented by inquiry strategies to seventh grade students in the inner-city with special learning problems.

The curriculum materials developed were investigative in approach. They focused on the specific areas of "The Crisis in the Environment" as they related to the environmental conditions of Cleveland, Ohio, and the surrounding area. Observational and experimental activities were emphasized. A field trip to observe Lake Erie and the surrounding plant life was conducted. Experimental work by students encompassed a study of conditions required to support plant and animal life. Activity sheets to record observations and conclusions were distributed to the students for each observation and experiment. Suggested lesson plans with specific behavioral objectives, listing of materials, key questions, and lesson development accompanied the instructional materials.

To evaluate the effectiveness of the curriculum materials with reference to achievement, attitudes, and degree of inquiry-orientation, a study was conducted in an inner-city junior high school in Cleveland, Ohio for a two and one-half week period. The curriculum materials were presented to students enrolled in transition, seventh grade classes (students not ready for junior high school because of deficiencies in reading and arithmetic skills, study habits, attention span and/or self-image). After the seventh grade these students would join the main stream of students in moving from class to class. The curriculum materials were employed in one transition class of all girls (12 girls in Homeroom 160) and another transition class of all boys (22 boys in Homeroom 157). The control transition class (Homeroom 158) consisted of all girls (14 girls). The same science teacher taught all three transition classes.

An interaction analysis was conducted in the experimental transition class of all girls to determine percentage teacher-talk and student-talk and the indirect-direct ratio.

An achievement test, "Community of Living Things," to assess attainment of objectives and an interest inventory, "How I Feel About Changes in the Air, Water, and Soil Caused by Man," to assess a change in attitude were structured andimplemented. A t-test of the difference between independent sample means was employed for the achievement and interest inventory scores.

At the end of the two and one-half weeks of instruction with the curriculum materials, the science teacher of the transition classes reported that the students in the experimental sections (Homeroom 160 and Homeroom 157) were motivated and interested in the group investigation of their environment--the survival of the plants and fish under various conditions, the activity of the rats, and the observation of Lake Erie. Students requested more field trips after their field trip on foot to Lake Erie. Although the instructional materials and activities appealed to the transition students, the science teacher reported that the students were disinterested in the attitude inventory and achievement test. The form of the attitude inventory with five choices on the degree of agreement may have been perplexing although an example was presented to them.

In the achievement posttest, the mean of the experimental transition class of all girls (19.50) and the mean of the experimental transition class of all boys (18.14) were higher than the mean of the control transition class of all girls (16.93). However, neither difference was significant at the .05 level.

The confusion over the form of the attitude inventory reported by the science transition teacher may explain the higher mean of the control transition class of all girls (40.09) in comparison to the mean of the experimental transition class of all girls (36.92) and the mean of the experimental transition class of all boys (36.53). Neither difference was significant at the .05 level.

The interaction analysis on a selected portion of the videotape of the experimental transition class of girls indicated 71% teacher-talk and 25% pupil-talk. The teacher-talk is similar to the mean reported for 40 lecture-discussion periods of five teachers of inquiry-oriented BSCS biology by Parakh. The pupil-talk is higher than the mean reported in Parakh's study.*

Although the posttests of achievement did not indicate a significant higher difference in achievement or attitude for the experimental transition classes, the motivation and interest in participation were reported by the transition science teacher. With the inquiry approach, students achieved as well as students in the conventional classroom. The investigative approach as a technique to the study of the Community of Living Things--The Crisis in the Environment and What Action Can We Take to Control Environment? - has merit, perhaps, not shown statistically because of the limitation of the instrument in measuring motivational factors. This research was sponsored by a University of Akron Research Faculty Projects Grant.

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* Jal S. Parakh, "A Study of Teacher-Pupil Interaction in BSCS Yellow Version Biology Classes," The American Biology Teacher. XXX (December, 1968), pp. 841-8.

THE DEVELOPMENT AND EVALUATION OF PHYSICAL SCIENCE CURRICULUM MATERIALS DESIGNED TO IMPROVE THE ATTITUDES OF THE SECONDARY SCHOOL SLOW LEARNER

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The last fifteen years have seen the development of numerous new curriculum materials in science. These programs resulted from increasing dissatisfaction with the traditional presentation of science in the secondary schools. Soon after the beginning of this curriculum movement, Bruner (The Process of Education, 1959), warned that, "Improvements in the teaching of science and mathematics may very well accentuate the gaps already observable between the talented, average, and slow students in these subjects"(p. 10). Ten years later, Hurd (New Directions in Teaching Secondary School Science, 1969), agreed that the problem had indeed developed and suggested that it has been much simpler to exclude students from courses in the physical sciences than to develop materials that make it possible for all students to have some contact with this branch of science.

The purpose of this study was to develop and evaluate physical science curriculum materials suitable for use with the secondary school slow learner. The primary phase of the study was the identification, from the literature dealing with the characteristics of the slow learner, of the educational strengths and weaknesses of the slow learner. Guidelines for the development of curriculum materials which take advantage of the strengths and compensate for the weaknesses were developed.

In the second phase, these guidelines were followed in the preparation of physical science curriculum materials. These materials, designed to cover approximately a six weeks period, included nine laboratory activities and five reading materials. Also included with the materials was a teacher's guide. This guide placed emphasis on developing the proper classroom atmosphere for use of the student materials.

The final phase was an evaluation of the effect of these materials on student attitudes toward science instruction. Evaluation was primarily concerned with the effect of these materials on student attitudes toward science instruction, but also attempted to anticipate and account for the effect of other factors on student attitudes.

The basic research design used in the evaluative phase of this study is illustrated in Figure 1.

FIGURE 1

DESIGN OF THE EVALUATION

Experimental Group	Pretest	Treatment	Posttest
Control Group	Pretest	No Treatment	Posttest

This research design is a nonequivalent control group design, one of the more widely used experimental designs in educational research. The initial sampling does not provide for equivalence, but rather, the experimental and control groups constitute naturally assembled collectives. This method is considered an acceptable alternate when, as in the case of this study, random assignment of students to groups was not possible. The experimental and control groups were administered Osgood's Semantic Differential (The Measurement of Meaning, 1967) as a pretest. The experimental group received a treatment: the presentation of the physical science curriculum materials. The control group did not receive the treatment. Six weeks later both groups are administered the Semantic Differential as a posttest.

Conclusions from the analysis of data resulting from the evaluation may be summarized as follows:

1. The presentation of the physical science curriculum materials did significantly improve the attitudes toward science class and science laboratory of a sample of secondary school slow learners.

2. This improved attitude could not be attributed to the major effects of variables introduced by the nonrandom assignment experimental design.

3. The changes were not due to an interaction between any measured initial attitudes and the final attitudes in these areas.

4. It appears that some changes in student attitudes toward their science teacher occurred. However, these changes were not statistically significant.

5. While some positive changes in attitude toward school and the topic did appear in the experimental group, these changes were not gross enough to be considered statistically significant.

This project was undertaken in response to an extreme deficiency in available physical science curriculum materials designed to be used by the secondary school slow learner. This study was an attempt to advance procedures and materials that would satisfy the definition of an exploratory study without being completely invalidated by errors in design. The author feels that the results of the study have demonstrated an approach for developing materials in this area. It is hoped that this study will be considered suggestive of a direction in which to proceed when developing and evaluating physical science materials for the secondary school slow learner.

THE EFFECTS OF PERFORMANCE OBJECTIVES ON THE ACHIEVEMENT LEVEL OF SELECTED EIGHTH-GRADE SCIENCE PUPILS IN FOUR PREDOMINANTLY BLACK INNER CITY SCHOOLS

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The purpose of the study was to determine the effects of expressing course objectives in specific behavioral terms (performance objectives) on the achievement level of low achieving eighth-grade science pupils in four predominantly black inner city schools in Cincinnati, Ohio. Six teachers participated in the study and each teacher taught two classes. Two hundred and ten pupils were involved in the study. Three teachers were trained to develop and use performance objectives as an instructional technique. Pedagogical techniques ordinarily used in instruction by the other three teachers were not altered. A criterion test was developed by both trained and untrained teachers and was administered to the pupils at the end of the study.

Experimental groups consisted of (1) pupils and teachers who were given the objectives, (2) teachers who were given the objectives, (3) pupils who were given the objectives, and (4) pupils and teachers neither of whom were given the objectives. The independent variables were Treatments (given or not given the objectives), Sex of the pupil, Trained or untrained teacher, and Individual teachers. Performance on the Criterion measure was the dependent variable.

Data from the study were analyzed as follows: (1) A one-way analysis of variance was used to determine homogeneity of classes on the covariate mean (I.Q.); (2) A 2 x 2 x 2 x 3 analysis of covariance for a randomized group design was used to determine significance of treatments. The intelligence quotient score of each pupil was used as the covariate; (3) Duncan's New Multiple Range Test was used to compare performance mean scores among experimental groups; and (4) A subjective evaluation of statements of attitudes and opinions from both teachers and pupils was used.

There were no significant differences among classes on the covariate class means (I.Q.) or in performance on the criterion test which could be attributed to treatments (given or not given the objectives) or to the sex of the individual pupil. It was concluded (1) that differences in covariate means should not be considered an important factor influencing class performance on the criterion measure, (2) that the use of performance objectives as an instructional technique and the traditional methods of teaching may be equally effective, and (3) that the sex of the pupils had little influence on the level of achievement they attained. There were significant effects on pupils' achievement attributable to the training of the teacher ($p < .05$) and to differences in individual teachers ($p < .001$). It was concluded (1) that pupils taught by teachers trained in the use and development of performance objectives performed better on the criterion measure, and (2) that the achievement level a pupil attains may be greatly influenced by the pedagogical techniques the teacher uses during instruction. There was a highly significant interaction effect ($p < .001$) between Groups of teachers and Individual teachers. It was concluded that the interaction was a function of the achievement of the pupils of one of the trained teachers. The pupils of this teacher who were given the objectives did very poorly on the achievement measure. However, the class which did not receive the objectives did relatively well when compared to the achievement of the other classes. Providing pupils with the objectives improved (1) their understanding of what was expected of them and (2) their ability to work independently and/or in small groups. Teachers who used performance objectives were more aware of spontaneous developments that occurred in the classroom and exhibited greater confidence in their ability to design effective instructional programs and materials.

The teacher remains an important factor in determining the success or failure of pedagogical techniques used in instructing the low achiever. The use of performance objectives appeared to facilitate the presentation of course content in small manageable pieces thus providing greater opportunities for the low achiever to experience success in the classroom. It is recommended that further research be conducted whereby (1) more effective techniques for teaching the low achiever are developed and implemented, (2) those qualities possessed by effective teachers of low achievers can be identified and incorporated in the training of all teachers.

LEARNING ACHIEVEMENT AND THE EFFICIENCY OF LEARNING THE CONCEPT OF VECTOR ADDITION AT THREE DIFFERENT GRADE LEVELS

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The objectives of the study are described as follows: (1) To examine possible differences in ability to learn meaningfully the concept of vector addition in grades eight, nine, and ten, with learning time and I.Q. held constant; (2) To study the relationship between the ability of students to incorporate information into cognitive structure with varying degrees of clarity and stability, and their ability to learn new but related material six weeks later.

The earlier learning material, presented to 285 students in grades eight, nine, and ten, included four 40 minute audio-tutorial lessons. In lessons one and two students reviewed the skills necessary to learn addition of vectors. Lessons three and four were designed to teach vector addition at a pre-algebra level of sophistication.

One-fourth of the students took a posttest three days after completing the last session. Likewise one-fourth took the posttest three weeks and six weeks after the lessons.

The remaining one-fourth (72 students) studied some related material on resolution of vectors six weeks after the last learning session rather than take a test over the material on vector addition. The related material was in a programmed instruction format, studied for 25 minutes, and then immediately followed by a posttest.

The general conclusions are described as follows: (1) In contrast to eighth grade and low ability ninth grade students, high ability ninth and all tenth grade students, were able to incorporate the learning material on vector addition into cognitive structure with clarity and stability in the 80 minute time period. Further, the learning material had enough stability and clarity that it could be utilized as subsuming concepts for the learning of a related task six weeks later. (2) Though low ability ninth grade and all eighth grade students were able to learn the original material on vector addition to some extent, it was not stable enough nor clear enough, to be useful for the learning of a related learning task six weeks later. (3) The most general finding was that, with learning time and I.Q. held constant, achievement in this subject matter sub-area was nearly linearly related to grade level.

CONCEPT FORMATION BY JUNIOR HIGH SCHOOL STUDENTS USING INDUCTIVE METHODS

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This research considers how students in an inductive inquiry situation make use of data or input provided by the teacher. The study also points to one of the problems in writing curricula. The curriculum researcher finds that the student modifies the input of the researcher, resulting in output different than that desired. This suggests that, instead of ignoring student modifications, these modifications may be proper starting points for curriculum development.

The study is descriptive and makes use of student drawings and comments by students about their drawings. The study was carried out during the Spring of 1970 at the Urbana Junior High School, Urbana, Illinois. The subjects of the study were ninth grade students enrolled in two heterogeneously grouped biology classes. The wide variation in ability presented no problems and provided a wider range of responses for analysis.

In this study this writer gave the students cell preparations to observe and describe. The only direction from the teacher was that of technique or how to prepare specimens for examination. Two questions were posed as part of the study. First, would the students' observation of cell preparations be sufficient to enable them to draw cells and their parts? Second, would the empirical data that the students could gather be adequate to develop the concept of the structural unit called the cell? A third question was asked, but it was not part of the present study. If the empirical evidence does not allow students to develop the concept of the cell, what is necessary? Is it possible, through inquiry, to "discover" the cell?

The results of the study illustrate one of the problems students face when they are confronted with empirical data and no readily apparent conceptual guidelines. Most of the students were capable of using the term cell, i.e. they could say it, but in data gathering situations they were not always able to draw cells when confronted with a preparation containing them. Other students were able to reproduce the essential features of cells but were not able to relate the term cell to what they had drawn. The finding is in accord with Hanson's views on the influence of conceptual schemes on scientific observation.

The conclusion seems to be that the students see the data differently than does the educator. The student is more in the position of a researcher seeking an explanation of his data. The educator is in the position of the historian-philosopher-logician. The educator is committed to a right answer. Further, it must be said that the educator is forced, by this situation, into finding a logically consistent method of moving from the student's position to one more in line with what the educator knows is right.

Session Id - Secondary School Science--Curriculum, Evaluation, and Innovation

Chairman: Michael Cohen, Purdue University at Indianapolis, Indianapolis, Indiana

1. "An Experimental Study of Computer Reinforced and Inductive Techniques in High School Chemistry Laboratory Sessions," John R. Shafer, West Irondequoit Central School District, Rochester, New York, and John J. Montean, The University of Rochester, Rochester, New York.
2. "Problems Concerning Use of Item Analysis Data in Curriculum Evaluation," Hulda Grobman, New York University, New York, New York.
3. "The Appraisal of Two Objectives of the High School Teacher's Guide for Chemistry (1968) of the Philadelphia Public Schools," Lowell A. Seymour, Philadelphia School District, Philadelphia, Pennsylvania.
4. "An Evaluation of the Achievement of General Course Objectives for a Secondary Biology Program," Thomas J. Grgurich, Cherry Hill High School East, Cherry Hill, New Jersey.
5. "Individualized Chemistry for High School Students," Donald P. Altieri and Paul A. Becht, University of Florida, Gainesville, Florida.
6. "Environmental and Other Societal Issues: The Development of an Attitude Instrument and Its Use with Secondary School Teachers," Richard Barnhart, Oregon State University, Corvallis, Oregon.

AN EXPERIMENTAL STUDY OF COMPUTER REINFORCED AND INDUCTIVE TECHNIQUES IN HIGH SCHOOL CHEMISTRY LABORATORY SESSIONS

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and

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A study was conducted to determine whether the use of the computer as a reinforcement tool and the use of the inductive method of instruction in the chemistry laboratory produce higher achievement scores than do more traditional methods. Five teachers and approximately 350 students in a large suburban high school were involved in the study. Twenty-four laboratory sections were randomly assigned, six to each of four groups: Group 1 used an inductive method and the computer; Group 2 used an inductive method and did not use the computer; Group 3 used a conventional method and the computer; Group 4 used a conventional method and did not use the computer.

Only those students taking the New York State Regents examination in chemistry were involved in the study, which lasted for five months. All students were given pretests consisting of a chemistry achievement test, the Watson-Glaser Critical Thinking Appraisal, and the Test on Understanding Science (TOUS). Posttests used were the Cooperative Chemistry Achievement Test - Part II, the Watson-Glaser Critical Thinking Appraisal, and the TOUS.

The data were treated by a two-way analysis of covariance with the scores on the pretests as the covariables and the scores on the posttests as the dependent variables. Results showed that inductive class sessions and using a computer as a reinforcement tool were as effective as the conventional laboratory in teaching facts and principles of chemistry and in developing non-specific critical thinking abilities.

Statistically significant differences among the four groups were observed only on the TOUS. Groups 1, 2, and 3 were higher than Group 4 in mean score gain on TOUS. (Group 4 actually had a mean loss of 0.12 points from pretest to posttest.) In the first three groups the students were required to analyze and work with their data; there were no such requirements for Group 4. The effect of using the inductive method alone was greater than the effect of using the computer alone.

The results of this study indicate that the inductive approach and/or the use of the computer in chemistry laboratory instruction increases the student's understanding of science, whereas conventional laboratory instruction does not.

PROBLEMS CONCERNING USE OF ITEM ANALYSIS DATA IN CURRICULUM EVALUATION

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In the literature, most discussions of the interpretation of item analysis data are concerned with construction and validation of standardized tests and the interpretation of students' scores on such tests. Recently, achievement tests have been widely used in the formative evaluation of developmental curriculum materials, for purposes of feeding back, during the tryout period, information on student achievement that will provide guides for curriculum revision and supplementation. It has been tacitly assumed that item data obtained for such tests of developmental materials would be used in much the same way that comparable data have been used in development and interpretation of standardized tests; little attention has been given to the differences in function, differences in standards of acceptability, and the problems of interpretation of item data in formative evaluation.

This paper will use some 25 items from tests administered during the formative evaluation of Interaction of Man and Biosphere (Rand McNally, Chicago, Illinois, 1970) to illustrate some unique considerations concerning data in such evaluations and some of the problems of interpreting such item data. These include: (a) appropriate range of difficulty of items; (b) wide fluctuations in difficulty level between different years for a specific item; (c) wide fluctuations of biserial correlation between different years for a specific item; and (d) appropriate biserial correlation criterion for an acceptable item.

Hypotheses will be proposed to explain why data on some items fluctuate while they are relatively stable for others, some possible causes in terms of situational variables (teachers, students, schools) and curriculum variables (differences among experimental editions), and the implications for curriculum evaluation and test development.

THE APPRAISAL OF TWO OBJECTIVES OF THE HIGH SCHOOL TEACHER'S GUIDE FOR CHEMISTRY (1968) OF THE PHILADELPHIA PUBLIC SCHOOLS

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Philadelphia School District
Philadelphia, Pennsylvania

This study involved the appraisal of three aspects of two objectives listed in the high school chemistry guide for the Philadelphia Public School District. The two objectives selected for study were:

(1) To develop an understanding of scientific inquiry,
(2) To promote the development of scientific literacy.

Three aspects of these two objectives were selected for detailed study. They were:

(1) The development of critical thinking ability,
(2) The development of open-mindedness,
(3) The development of knowledge of the processes of science.

The criterion measures utilized to study the above aspects were the Watson-Glaser Critical Thinking Appraisal - Form YM, the Rokeach Dogmatism Scale - Form E, and the Wisconsin Inventory of Science Processes.

The students selected for study were eleventh grade students from two comprehensive high schools in Philadelphia. Chemistry classes were randomly subdivided into two experimental groups: Experimental Group One which was pre- and post-tested, and Experimental Group Three which was post-tested only. Non-chemistry students were matched by sex and intelligence quotients to the chemistry students. The non-chemistry students comprised Control Group Two which was both pre- and post-tested. The two experimental groups had four months of chemistry instruction.

The intelligence quotient scores for the sample were obtained for most eleventh grade chemistry and non-chemistry students and these scores served as a basis for dividing the experimental and control groups into three sub-groups. These three sub-groups were designated above-average, average, and below-average.

A three by two analysis of variance model was utilized to analyze the pre-test data. The results from this analysis indicated that Experimental Group One and Control Group Two were equivalent in their ability to think critically, open-mindedness, and knowledge of the processes of science.

An analysis of variance for repeated measures model was utilized to determine the pre- to post-test development of students on the three criterion measures. The results were: Control Group Two showed no significant development in their ability to think critically, open-mindedness, and knowledge of the processes of science. Chemistry students in Experimental Group One significantly developed their ability to think critically, but they did not change their open-mindedness and their knowledge of the processes of science decreased.

Further analyses of the data revealed that:

1. After one semester, the above-average chemistry students had significantly higher critical thinking ability than the average students. The above-average students were more open-minded and knowledgeable of the processes of science than average, but these results were **not** significant at the 0.05 level.

2. After one semester, chemistry students in Experimental Group One had significantly higher critical thinking ability and greater open-mindedness, and lesser (not significant) knowledge of the processes of science than the non-chemistry students in Control Group Two.

3. After one semester, chemistry students in Experimental Group Three were equivalent to the non-chemistry students in Control Group Two in critical thinking ability, open-mindedness, and knowledge of the processes of science.

AN EVALUATION OF THE ACHIEVEMENT OF GENERAL COURSE OBJECTIVES FOR A SECONDARY BIOLOGY PROGRAM

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The purpose of this study was to evaluate the achievement in biology of selected pre-determined general course objectives by A, B, and C ability grouped tenth grade students of the Cherry Hill School System in Cherry Hill, New Jersey. The students were exposed to the Blue Version BSCS Biology course, the Yellow Version BSCS Biology course, and a general survey Biology course respectively. Pretest and posttest mean gains and sex relationship to objective achievement were also evaluated.

A nonequivalent control group design was used to evalute achievement of the general course objectives of increased scientific literacy, increased understanding of and ability to use the processes of science, and increased interest in science in general and biology in particular. The evaluation instruments chosen as indicative of achievement of the general course objectives included the _Nelson Biology Test_, the _Comprehensive Final Examination_, the _Test on Understanding Science_, the _Processes of Science Test_, the _Watson-Glaser Critical Thinking Appraisal_, the _Kuder Preference Record Vocational_, and _A Scale to Measure Attitude Toward Any School Subject_. Each ability group was evaluated separately for the dependent variables chosen as indicative of objective achievement. The ability group samples included 27 A experimental students, 25 A control students, 37 B experimental students, 37 B control students, 40 C experimental students, and 40 C control students. A covariant t test was used to evaluate the significance of the data for the sixteen dependent variables indicative of achievement of the three general objectives under study.

The following conclusions were supported by the data:

1. A ability grouped tenth graders in the Blue Version course partially achieved increased scientific literacy, but did not achieve increased ability to understand and use the processes of science or increased interest in science and biology.

2. Sex was a significant factor on some measures of ability to understand and use the processes of science and of interest in science and biology, but was not a significant factor on measures of scientific literacy for A ability grouped tenth graders in the Blue Version course or no science course. Males achieved greater means on interest measures while females achieved greater means on measures of the processes of science.

3. Experimental A ability grouped tenth graders in the Blue Version course achieved significant mean gains from pretest to posttest on most measures of scientific literacy and ability to understand and use the processes of science, but not on measures of interest in science and biology.

4. Control non-science A ability grouped tenth graders achieved significant mean gains from pretest to posttest on some measures of scientific literacy and ability to understand and use the processes of science, but not on measures of interest in science and biology.

5. B ability grouped tenth graders in the Yellow Version course achieved increased scientific literacy and ability to understand and use the processes of science on several measures, but did not achieve increased interest in science and biology.

6. Sex was a significant factor on one measure of interest in science, but was not a significant factor on measures of scientific literacy or ability to understand and use the processes of science for B ability grouped tenth graders in the Yellow Version course or no science course. Males achieved a greater mean in interest in science.

7. Experimental B ability grouped tenth graders in the Yellow Version course achieved significant mean gains from pretest to posttest on most measures of scientific literacy and ability to understand and use the processes of science, but not on measures of interest in science and biology.

8. Control non-science B ability grouped tenth graders achieved significant mean gains from pretest to posttest on some measures of scientific literacy and ability to understand and use the processes of science, but not on measures of interest in science and biology.

9. C ability grouped tenth graders in the general Biology course achieved increased scientific literacy on one measure and increased interest in science and biology on two measures, but did not achieve increased ability to understand and use the processes of science.

10. Sex was a significant factor on one measure of scientific literacy and on two measures of interest in science and biology, but was not a significant factor on measuresof ability to understand and use the processes of science for C ability grouped tenth graders in the general Biology course or no science course. Males achieved the greater means on all significant results.

11. Experimental C ability grouped tenth graders in the general Biology course achieved significant mean gains from pretest to posttest on one measure of scientific literacy, but not on measures of ability to understand and use the processes of science or interest in science and biology.

12. Control non-science C ability grouped tenth graders did not achieve significant mean gains from pretest to posttest on measures of scientific literacy or interest in science and biology, but did achieve significant mean gains on two measures of ability to understand and use the processes of science.

It is apparent from these findings that pre-determined general course objectives for given ability groups of secondary students exposed to selected biology courses can be taught for and achieved with varying degrees of success.

INDIVIDUALIZED CHEMISTRY FOR HIGH SCHOOL STUDENTS

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and
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P. K. Yonge Laboratory School, University of Florida, Gainesville, Florida, developed a new curriculum in chemistry designed around the concept of individualized instruction. The curriculum was designed with two main objectives in mind: 1) the student will obtain a better understanding of concepts in chemistry through individualization in the classroom; 2) the student will pursue his study of chemistry at his own, predetermined rate with the assistance of the teacher. This curriculum was used as a pilot program at P. K. Yonge Lab School during the 1969-70 school year. This year P. K. Yonge received a grant to field test the curriculum in ten high schools throughout the state of Florida.

This paper discusses the development of the curriculum and the experimental design of the field testing project. The ramifications of the individualized chemistry curriculum possibly becoming a nationally adopted chemistry curriculum are also discussed.

ENVIRONMENTAL AND OTHER SOCIETAL ISSUES: THE DEVELOPMENT OF AN ATTITUDE INSTRUMENT AND ITS USE WITH SECONDARY SCHOOL TEACHERS

Richard Barnhart
Oregon State University
Corvallis, Oregon

The present focus on societal issues, including environmental concerns, was noted, and the implications for science education were examined. From these considerations a need was seen for assessing teacher attitudes toward societal issues, especially those related to science. Such an assessment required: (1) identification of the structure underlying these attitudes; (2) construction of attitude scales representative of that structure.

Steps employed for instrument development were described as follows:

(1) A broad definition of a universe of attitude referents was stated.

(2) A multitude of sources was used to identify referents.

(3) Likert type attitude statements were constructed from these referents and a five point response format was employed.

(4) Responses and comments were solicited from university students and the results used to identify ambiguous or non-appealing, non-discriminating items for elimination or revision.

(5) A pilot group of high school students was used as the final test of the resulting items.

In all, approximately two hundred fifty items were considered from which one hundred were chosen for use in a preliminary inventory. These one hundred items were administered to about three hundred high school seniors in the State of Oregon.

The responses of these seniors were factor analyzed to determine the structure of the universe of referents represented by the inventory. A sub-universe represented by sixty items and seven interpretable factors was identified. This final inventory was named the Inventory of Societal Issues (ISI). It was developed jointly with another researcher.

The factors were identified as follows:

(1) Regard for human life. Special referents included abortion, euthanasia and drug use.

(2) Desire for a return to laissez-faire with respect to nature. Fatalistic disillusionment with "progress" as represented by scientific and technological advances was evidenced.

(3) Need to cooperate with nature rather than subjegate it. Conservation and preservation were stressed.

(4) Concern with control of population and its related problems. Both population and authority were present as referents.

(5) Need to take personal responsibility for societal woes. Specific references were made to personal conveniences, luxuries and enjoyments.

(6) Belief in the utility of science and technology and their ability to solve many of society's problems.

(7) Desire to have and allow individual freedom.

Approximately seven hundred Oregon secondary school teachers were asked to respond to the ISI. The sample consisted of nearly an equal number of science teachers and teachers from areas other than science. Teacher scores on each of the seven factors were used as criterion variables for an analysis of covariance. The independent variable of major interest was science vs non-science teaching area.

Session Ie - Elementary School Science--Learning, Behavior and Performance

Chairman: Doris Trojcak, University of Missouri, Columbia, Missouri

1. "A Branch Analysis of Graphing Behavior in Two Learning Hierarchies Within Piagetian Stages," Vincent D. Mahoney, Iowa Wesleyan College, Mt. Pleasant, Iowa.
2. "The Effect of Method of Instruction and Mode of Response Upon Criterion Performance," Cornelius J. Troost and Stanley Morris, University of California at Los Angeles, Los Angeles, California
3. "A Comparative Study of the Effect of Certain Factors on the Teaching Behavior of Preservice Elementary Teachers of Science," R. Scott Irwin, Kansas State Teachers College, Emporia, Kansas and David P. Butts, University of Texas at Austin, Austin, Texas.
4. "The Relative Effects of Alternative Instructional Sequences Including Interaction Analysis and Piaget-Type Interviews on Teacher Concerns and Behavior in Elementary School Science," Linda Jones, San Fernando State College, San Fernando, California and David P. Butts, University of Texas at Austin, Austin, Texas.
5. "A Descriptive Case Study of an Elementary Teacher Education Program of Science, Mathematics, and Reading for Experienced Teachers," Evan A. Sweetser, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.
6. "Information Theory Applied to the Analysis of Problem Solving Using the Parallel Circuit Model," Barbara K. Felen, Gene W. Moser and Willard W. Korth, University of Pittsburgh, Pittsburgh, Pennsylvania.

A BRANCH ANALYSIS OF GRAPHING BEHAVIOR IN TWO LEARNING HIERARCHIES WITHIN PIAGETIAN STAGES

Vincent D. Mahoney
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Mt. Pleasant, Iowa

The problem was to investigate at what intellectual levels of understanding students of ages nine through fourteen were to be found in the drawing and interpretation of line graphs related to simple physical variables of elementary school science.

These experimental hypotheses were used:

1. Was there a fixed order in which concepts about linear and curved line graph drawing and interpretation are acquired by students increasing in ability to use complex logical operations?

2. Did individual students differ in the pattern of learning sets they achieved within two hierarchies of relevant learning sets on line graph drawing and line graph interpretation?

3. Did an increasing number of individuals at higher grade levels attain the learning sets of the hierarchies at progressively higher levels?

4. Did the non-conservers progress as far upwards in the two learning hierarchies as those termed conservers?

5. What were the relative performances on the graphing hierarchies for students at the concrete operations stage and at the formal operations stage of cognitive development?

After a pilot study to validate the two graphing hierarchies and to test the set of eight Piagetian conservation tasks, the main study was conducted within grades four through eight across three socio-economic levels (upper, middle, and lower). A total of fifteen classes or five classes per S.E.S. level (N=365) were given the Piaget conservation tasks and then the two graphing booklets.

There was a dominant order reflected by general student performance on the graphing tasks of both hierarchies. For drawing a line graph, the apparent order of tasks from easy to difficult was plotting points on a graph from a data table, writing a data table of numerical pairs from a graph, picking a "best-fit" line from a series of lines on a graph, labeling axes on a graph, writing numerical scales on a graph, drawing a "best-fit" line through plotted points, drawing a total straight line graph, and drawing a total curved line graph.

For interpreting a line graph, the sequence of tasks from easy to hard was stating a change in one variable as the other one changed, interpolating values from a graph line, stating ratios from a line graph, stating trends numerically, stating trends verbally, stating rates, extrapolating values from a graph line, fully interpreting a straight line graph, and fully interpreting a curved line graph.

An increasing number of students at higher grade levels (formal thinkers especially) attained more of the learning sets at higher levels in both hierarchies. Five of the eight tasks for drawing a line graph were dependently associated with concrete and formal thinking level. Seven of the nine tasks in the interpreting hierarchy were dependently associated with concrete and formal operational thinking level.

The non-conservers or pre-operational thinkers attained considerably fewer of the higher tasks in both learning hierarchies than did the conservers or concrete operational thinkers. The formal operational thinkers outperformed the concrete operational thinkers on every task of both hierarchies as to relative percentages of each group.

THE EFFECT OF METHOD OF INSTRUCTION AND MODE OF RESPONSE UPON CRITERION PERFORMANCE

Cornelius J. Troost

and

Stanley Morris
University of California
Los Angeles, California

The purpose of this study was to compare the relative effectiveness of three instructional approaches: lecture (expository method), videotaped lecture--demonstration, and a linear program, as evaluated by results on a criterion test. Efforts were made to control the mode of response variable in each treatment situation so that the effect of mode of response on criterion performance was evaluated.

It was hypothesized that a comparison of the three teaching methods at any of three chosen levels of frequency of response would yield no significant differences as measured by performance on a criterion test. The levels of frequency of response were 100 per cent or full overt response, 33 per cent or partial-overt, and no (covert response). Furthermore, it was hypothesized that no significant difference exists among levels of frequency of response at any of the teaching method levels.

The authors developed a linear program based upon Newton's Second Law. After a task analysis was worked out for Newton's Law, the linear program and a criterion test were developed which related directly to the major concepts of the task analysis. The criterion test consisted of 10 multiple-choice type problems.

After the pilot study, the sample group became sixth grade students (N=243) in three middle-class schools in the Los Angeles area. These subjects were divided into nine subsamples of 27 each. The subsample was composed of intact classes randomly assigned to nine treatment combinations.

A randomized factorial design was used. The statistical technique was an ANOVA program, BMD08V, using the Campus Computing Facility.

The first hypothesis was confirmed. That is, no significant difference in criterion performance exists among the teaching methods at any of the three levels of response. Secondly, there was a significant difference between modes of response at different teaching method levels. The difference favored the full overt response mode.

The study indicates that none of the three teaching methods was significantly better than the others in promoting conceptual understanding of Newton's Second Law. The mode (frequency) of response treatment showed significant differences in favor of overt responsing. If one wishes to bring about an understanding of a difficult concept, a linear program plus full overt responding is apparently the best instructional approach, providing the amount of time is nearly equal.

It is assumed that frequency of response is a factor largely conditioned by prior experience. That is, where students have attuned themselves to passivity in a lecture situation, the insistence that they respond overtly, even in problem-solving activities, may constitute interference with established habit patterns. Conversely, the demand that they respond covertly to a linear program is a contradiction of their expectations. Given consanguinity between expectancy and task, students apparently perform better on a conceptually oriented criterion test if they respond overtly 100 per cent of the time.

A COMPARATIVE STUDY OF THE EFFECT OF CERTAIN FACTORS ON THE TEACHING BEHAVIOR OF PRESERVICE ELEMENTARY TEACHERS OF SCIENCE

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and

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The University of Texas at Austin
Austin, Texas

Within the past decade, a number of elementary science curricula have been developed, field tested, revised, and widely implemented. These curricula place an emphasis on the teacher's role as a guide in student-centered science activities. Such curricula have helped form criteria with which colleges and universities concerned with undergraduate teacher education are searching for relevant, productive experiences for tomorrow's beginning teachers. A seemingly logical line of pursuit of effective teacher education experiences centers around teaching--its practice and analysis. Many components of teaching have been described, tested, and found to influence the patterns of interaction between teacher and child. Because the child and the instructional task are considered basic ingredients in any teaching situation, yet stand relatively untested in terms of their influence on teaching behavior, a basic problem is presented: To what extent do the child and the instructional task influence the teaching behavior of preservice elementary teachers?

The subjects for this study were senior-level elementary education majorsenrolled in six sections of an experimental elementary science methods course offered at five Texas colleges during the fall semester, 1969.

The demonstration of certain patterns of interaction between teacher and child is a measurable outcome by which to assess the influence of these two components. Tests of differences in mean pre- and post-instruction scores on eighteen factors of teaching behavior were analyzed for 86 subjects. The subjects were randomly assigned to three treatment groups. All groups received instruction in the use of interaction analysis. Group 1 subjects taught the same science lesson (pre and post-instruction) to different pairs of children, in a one-to-two low-ratio setting; Group 2 subjects taught different pre-post science lessons to the same pair of children; and Group 3 subjects taught different pre-post science lessons to different pairs of children. All children were of second or third grade level.

Both first and second lessons taught by all subjects were recorded on audiotapes and analyzed using the 32-category Instrument for the Analysis of Science Teaching (IAST v. 2). Group mean scores on 18 specified patterns of interaction were computed from the matrices of all subjects lessons. The group means were analyzed using one-way analysis of variance.

Two principal conclusions drawn from this study are: (1) The effect of instruction in the use of interaction analysis, in which subjects from all treatment groups participated, produced more similarities than differences in changes of the teaching behavior of preservice elementary teachers of science, and (2) where differences occurred, the children taught influenced teaching behavior more than the instructional task.

THE RELATIVE EFFECTS OF ALTERNATIVE INSTRUCTIONAL SEQUENCES INCLUDING INTERACTION ANALYSIS AND PIAGET-TYPE INTERVIEWS ON TEACHER CONCERNS AND BEHAVIOR IN ELEMENTARY SCHOOL SCIENCE

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and

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The lack of teaching experience by preservice teachers appears to be a serious hindrance to their perception of relevance in education course content. Fuller's (1969) conceptualization of teacher concerns is closely related to relevance perception. It was felt that an introductory experience might be devised which would mitigate this problem. Two experiences designed to develop perceptual frameworks (means for bringing education course content into personal relevance) were tested in this study. This study examined the effects of two experimental and one control experiences on change in teacher behavior and concern level.

Forty-nine beginning preservice teachers were randomly assigned to one of three treatments: (1) training in interaction analysis, (2) training in conducting and interpreting Piaget-type interviews with children, and (3) a control treatment of elementary school science methods. The treatments were given during the first two weeks of the semester. Teacher behavior and concern level were measured on a pre-, post-, delayed-post basis. Science lessons, taught one-to-one to elementary pupils by the subjects, were analyzed by the Instrument for Analysis of Science Teaching (Hall) for behavior data.

Using analysis of covariance with pretest scores as the covariate, the results were as follows:

1. Type of introductory experience made no difference in change in concern level. Concern levels increased immediately after treatment but decreased to initial levels by the end of the semester, regardless of type of treatment.

2. Type of introductory experience made little difference in teacher behavior change. One out of thirteen behavior factors tested showed significant findings. The interaction analysis group became more flexible than did the Piaget-type interviewing group.

It was concluded that flexibility may be the first behavior factor of those examined to be altered by interaction analysis training. More intensive training with successive behavior measures during and after treatments was recommended to determine other differentiations in treatment effects. Repeat of the study with more advanced subjects would be of interest, particularly in regard to concern level.

A DESCRIPTIVE CASE STUDY OF AN ELEMENTARY TEACHER EDUCATION PROGRAM OF SCIENCE, MATHEMATICS, AND READING FOR EXPERIENCED TEACHERS

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This descriptive study was designed to identify and interpret the role of the twenty-three Experienced Teacher Fellowship Program (EXTFP) participants in the subjects of science, mathematics and reading when they returned to their school systems following the 1966-67 Experienced Teacher Fellowship Program at Michigan State University. In addition, the study sought the EXTFP participants' evaluation of the Program with respect to their roles in science, mathematics and reading.

Specifically, the problem had two phases. Phase I investigated the EXTFP participants' perception of their own expected, desired and actual roles in science education in their 1967-68 education position. Areas of involvement were: assisting in science in-service education; helping other teachers obtain and use science equipment and materials; provide leadership and acting as change agents in innovation of science curriculum and teaching techniques; and continuing their professional growth.

The second phase of the problem was a case study of the EXTFP participants' actual role in science, mathematics and reading in the above mentioned activities. In Phase II of this study the participants' roles in science, mathematics and reading, as seen by their administrative superiors and co-workers, were recorded. Interviews by the investigator at the EXTFP participants' schools with the above persons constituted the basis of the case studies.

Prior to the Program, twenty-two of the participants were classroom teachers and one was a helping teacher. Following the Program, fifteen were classroom teachers, and eight were non-teachers (principals or supervisors). Nineteen were promoted to new or additional educational positions which varied from chairman of the district mathematics or science committee to the position of principal.

All EXTFP participants acknowledged that promotions to their new positions, or their specific activities were the direct result of the EXTFP. They all indicated that they had helped fellow teachers informally and shared equipment and materials developed in the EXTFP.

The participants rated their expected role higher than their desired role which in turn was rated higher than their actual role in science. In general they found their in-service activities limited. All participants were pleased with the Program, which had changed their instruction from the didactic method to the inductive method of teaching.

The Experienced Teacher Fellowship Program successfully met its goals of improving the teaching skills and knowledge of the participants and influencing change in the EXTFP participants' schools. But such change was limited by the administrative structure of the school. The administrators were not fully utilizing the potential leadership of the EXTFP participants because of a lack of communication between all parties. The cooperating school district would receive a greater benefit from the EXTFP participants' special training if the administrative personnel were informed as to how the participants' special training could best be used in their district. The EXTFP participant could be more effective as a resource person if he was given training emphasizing the role of the resource person acting as a change agent. The cooperating school district should file application jointly with the EXTFP applicant and make a firm commitment outlining proposed plans to use him as a resource person. The Program should make a commitment to the cooperating district to provide limited science equipment, materials, and consultant help for use by the EXTFP participant following his training.

INFORMATION THEORY APPLIED TO THE ANALYSIS OF PROBLEM SOLVING USING THE PARALLEL CIRCUIT MODEL

Barbara K. Felen, Gene W. Moser
and
Willard W. Korth
University of Pittsburgh
Pittsburgh, Pennsylvania

In recent years the ability to use knowledge rather than to store knowledge has become the focus of science education. The purpose of this investigation was to attempt to develop a model that could be used to gain some insight into the area of information processing. A workable understanding of the problem solving process is necessary if we wish to determine the efficiency of the information processing of children and if we wish to develop environments that would be beneficial to this information processing. Information theory may serve as a valuable tool in the development of this much needed measure of problem-solving behavior.

The sample for investigation was chosen from a population of second through eleventh graders in Allegheny County, Pennsylvania. Subjects were given one dry cell, one single-throw switch, two miniature light receptacles (with bulbs), and five wires. They were then instructed to put the components together so that both bulbs would light and if one bulb was unscrewed the other would remain lit. The various connections were recorded in sequence by the observer on an eight by eight matrix. At the conclusion of the problem solving session students were asked a series of questions in order to determine age, sex, and prior experience with electric circuits. Markovian Chain mathematical reasoning based on stochastic processes in conjunction with information theory was used in the analysis of results.

Successful students, for the most part, displayed more structuredness in their problem-solving processing. They had a low freedom of choice and a low uncertainty. Unsuccessful students, in contrast, operated in a more random fashion, and many appeared unwilling to attempt a solution. Relative entropy values contained in the M-matrices showing the total number of connections made in all blocks processed ranged from 4.2 percent to 59.2 percent for successful solutions and from 29.9 percent to 74.4 percent for unsuccessful solutions. Analysis of the information contained in the M^4 matrices showed low relative entropy values for successful students. The matrices of unsuccessful students rapidly approached states of independence. This approach was not as rapid in grades two and three due to the reluctance of students to make connections. Relative entropy values contained in the M^4 matrices showing the total number of connections made in all blocks processed ranged from zero to 97.8 percent for successful solutions and from 14.7 percent to 99.0 percent for unsuccessful solutions.

Interpretation of the information contained in the $(p-1) + (M^2)$ matrices showed that in the upper grades, the various relational components of the problem were more scattered over rows and columns than were the non-relational components for both successful and unsuccessful students. In turn, scatter appeared to be greater for successful students in the lower grades. The greatest implication of this study seems to lie in the fact that it may provide educators with a model based on Information Theory that could be used to systematically investigate problem-solving processes.

Concurrent Sessions II

Session IIa - College and University Science

Chairman: Robert Howe, Ohio State University, Columbus, Ohio

1. "Some Factors Contributing to Success in Science Fields at the University of Michigan," Elizabeth J. Mallon, St. John's University, Jamaica, New York.
2. "An Investigation of the Cognitive Teaching Behavior of a College Science Teaching Faculty," Lawrence H. Talley, West Liberty State College, West Liberty, West Virginia, and Gerald O. Solomon, West Virginia University, Morgantown, West Virginia.
3. "A Comparison of the Effectiveness of the Planetarium and the Classroom Chalkboard and Celestial Globe in the Teaching of Specific Astronomical Concepts," George Reed, West Chester State College, West Chester, Pennsylvania.
4. "Selected Characteristics of Science Majors in Predominantly Black Colleges," Michael P. Tilford, Wichita State University, Wichita, Kansas.
5. "Spatial Cognitive, A Success Prognosticator in College Science Courses," Francis T. Siemankowski and Franklin C. MacKnight, State University College, Buffalo, New York.
6. "The Design and Evaluation of an Auto-Tutorial Genetics Course to Increase Scientific Literacy Among Nonscience Majors," Bernard F. Gross, Syracuse University, Syracuse, New York.

SOME FACTORS CONTRIBUTING TO SUCCESS IN SCIENCE FIELDS AT THE UNIVERSITY OF MICHIGAN

Elizabeth Jane Mallon
St. John's University
Jamaica, New York

This study was designed to determine whether or not 231 students (206 men and 25 women) graduating from the University of Michigan during 1969 as majors in the sciences, dentistry, engineering, and medicine were adequately prepared by their high school, with three years each of science and mathematics, to major in science at the college level. The size of the high school from which they had graduated was used as the major factor in assessing this adequacy of preparation. Other factors such as socio-economic status, ethnic group, rating of the scope and quality of their high school science instruction, family size, sibling rank, sex, and person or persons responsible for the students' choice of science as a college major were studied. In essence, the survey attempted to verify James B. Conant's allegations that a high school with less than 750 students was unable to give a comprehensive education, including three years of science and mathematics, to those students planning on attending college or university.

Students from large high schools (enrollment of more than 1500) constituted 47.6 percent of the sample; from medium-sized high schools (enrollment of 1499-750), 23.8 percent from small high schools (enrollment less than 750), 28.6 percent of the sample.

A questionnaire was answered by these students pertaining to family background, scope and quality of high school science and mathematics instruction, and persons or persons influencing the student's choice of science as a major in college. High school and college records of these students were examined for high school percentile rank, college grade point average for 90 or more semester hours, results of National Merit Scholarship Examinations, and the Opinion, Attitude and Interest Survey results which includes the scores for College Entrance Examination Board tests.

In taking these factors into account, this study showed that:

1. The high school percentile rank and National Merit Scholarship Selection Score were the major factors in predicting success in science fields regardless of the size of the high school from which the student had graduated.

2. All 231 students had each taken three or more years of high school science and mathematics.

3. The students were predominantly Caucasian from upper middle class or upper class families with a mean number of three children and ranked first or second in sibling order.

4. All 231 students had a mean National Merit Scholarship Selection Score above the national mean but students from medium-sized high schools scored significantly higher than did students from large or small high schools.

5. All 231 students had mean College Entrance Examination Board-Mathematics scores above 640 with students from large high schools scoring higher than students from medium or small high schools.

6. Students from small high schools rated the quality of their high school science instruction and laboratory facilities lower than did students from large and medium-sized schools.

7. Most influence on the students' choice of science as a major in college was exerted by the family and the science high school teacher.

8. No significant differences were found in college grade point average for 90 or more semester hours. The mean average was 2.80 for students from small high schools, 2.79 from medium-sized high schools, and 2.72 from large schools.

Contrary to opinions expressed by Conant in The American High School Today and The Comprehensive High School, the size of the high school from which the 231 science majors at the University of Michigan had graduated had no effect on the adequacy of their high school science and mathematics preparation and college grade point average for 90 or more college semester hours.

AN INVESTIGATION OF THE COGNITIVE TEACHING BEHAVIOR OF A COLLEGE SCIENCE TEACHING FACULTY

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This study sought to investigate the cognitive teaching styles of the entire science teaching faculty at a four-year West Virginia college. Systematic observation instruments were utilized to determine specific behavior and to measure the consistency of this behavior both within and between separate courses taught by the same instructor. Selected non-science instructors were compared with science faculty in an attempt to detect changes in cognitive sytle with subject matter. Further, administrative and student rankings of staff effectiveness were correlated with the two cognitive dimensions treated. Multiple visitations were made. The TIP Profile and the FTCB were simultaneously scored at each visitation.

The TIP, developed by Solomon, is designed to assess teacher behavior on a concrete to abstract imagery related continuum. This continuum includes a lower concrete level, three imagery related middle levels, and a higher abstract level. Distinct patterns of imagery related cognitive teacher behavior are identified and the appropriateness with which teachers deal with students at differing levels of cognitive maturity can be subsequently evaluated by means of this instrument.

The FTCB, developed by Brown, Ober, and Soar, is an operationalized modification of Bloom's Taxonomy of Educational Objectives: Cognitive Domain. It includes a total of 55 single items which are further divided into seven subdimensions: Knowledge, Translation, Interpretation, Application, Analysis, Synthesis, and Evaluation. Provisions are made for measuring both teacher and student behaviors. Scoring procedures allow subscores for each of the seven subdimensions and a total composite score to be calculated for both teacher and student.

Analysis of the data from TIP and FTCB indicated that distinct teaching styles could be discerned along both the concrete-abstract and knowledge-evaluation level dimensions with the majority of behavior occurring on abstract and knowledge levels. Some differences in cognitive level were exhibited in laboratory vs. non-laboratory and in science vs. non-science instruction. The data suggested that the level of instructional abstractness shown did not necessarily vary with the difficulty of the subject matter. Finally, relationships between administrative opinion of teaching effectiveness and cognitive style were established.

A COMPARISON OF THE EFFECTIVENESS OF THE PLANETARIUM AND THE CLASSROOM CHALKBOARD AND CELESTIAL GLOBE IN THE TEACHING OF SPECIFIC ASTRONOMICAL CONCEPTS

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The planetarium is a simulation mechanism that shows the movements of the celestial bodies as they appear to an observer on the earth. Estimates made in 1967 showed that there were seven hundred planetaria in museums, civic centers, public schools and colleges, and that the number was growing at the rate of almost one hundred per year. The increased educational use of the planetarium has been the result of intuition and lacks a sound research base. This study was undertaken because of the need to evaluate the effectiveness of the planetarium as a teaching device.

The planetarium teaching situation was compared to the classroom chalkboard and celestial globe teaching situation in the teaching of selected astronomical concepts. The basic design of the experiment was the Posttest-Only Control Group design with the Randomized-Group technique. The experiment was conducted over a two-semester period using the same design and procedure but using different subjects and astronomical concepts each semester. The population consisted of West Chester State College students enrolled in a one-semester physical science course during the fall semester of 1969 and the spring semester of 1970. All the instruction in the planetarium and the chalkboard-globe teaching situations was given by the investigator.

The results of the cognitive behavioral objectives were analyzed by use of the student's t distribution and the t ratio. Tests were made for significant differences between the means of the planetarium groups and the chalkboard-globe groups as measured immediately following the presentation and between the two groups after periods of four, eight, and twelve weeks. The interval of time between the treatment and the posttest was used to measure retention. The affective behavioral objectives were analyzed by means of relative frequency graphs.

The Selected Astronomical Principles Test was developed because of the nonexistence of an available standardized test with regard to the content and stated objectives of the experiment. A jury of professional astronomers and planetarium directors established the content validity of the test. The reliability of the two parts of the test was established by means of two pilot studies.

The study identifies the chalkboard-globe teaching situation as the more efficient teaching situation with respect to the immediate attainment and retention of the cognitive behavioral objectives. The chalkboard-globe mean on the Selected Astronomical Principles Test was higher than the planetarium mean at all eight testings and was significantly higher at six of the eight testings. The study further indicates that the superiority of the chalkboard-globe teaching situation increases with an increase in the complexity of the astronomical concepts.

It was concluded that: (1) the chalkboard-globe teaching situation is significantly superior to the planetarium teaching situation with respect to the immediate attainment and retention of specific cognitive behavioral objectives; (2) there is no difference in the affective domain between the chalkboard-globe teaching situation and the planetarium teaching situation. The results of the study are in direct contrast to the numerous unsubstantiated claims by educators and planetarium directors.

SELECTED CHARACTERISTICS OF SCIENCE MAJORS IN PREDOMINANTLY BLACK COLLEGES

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The purpose of this investigation was to identify some of the characteristics of black college students who major in science in comparison to those who are non-science majors. It was designed to narrow the gap in our knowledge of the characteristics of scientists resulting from the omission of black scientists in previous studies.

The population consisted of the students in three predominantly Negro colleges; one in each of the states of Alabama, Texas, and Oklahoma. Twelve variables were investigated for their effect on major field of study and college attended.

These were: (1) ACT composite scores, (2) ACT science scores, (3) grade point averages, (4) high school science activity, (5) attitude toward science, (6) percentage of white students in high school, (7) high school influence on choice of major field, (8) family influence on choice of major field, (9) college influence on choice of major field, (10) socioeconomic status, (11) number of siblings, and (12) ordinal position among siblings. In addition, measures representing the variables "siblings with college" and "size of high school" were analyzed in a correlation matrix with some of the variables above for science majors only.

The instrument used in the investigation was a questionnaire consisting of free choice items relative to the characteristics selected. An original Likert-type scale was developed by the investigator to obtain a measure of "attitude toward science." This scale was incorporated into the questionnaire. The responses to the questionnaire were analyzed by analyses of variance, Pearson Product moment correlations, a t-test, and percentages. The science majors were subdivided into pure science and applied science groups for the analyses of variance on each of the twelve variables.

Pure science majors, applied science majors, and non-science majors were found to differ significantly on each of the measures of academic ability and achievement: ACT composite score, ACT science score, and grade point average. Applied science majors were similar to non-science majors on these measures. Measures of the family socioeconomic status, number of siblings, and ordinal position among siblings, failed to discriminate between the major field or college groups. The choice of a science or non-science major was not affected by the "percentage of white students" in high school. There were significant differences between the pure science, applied science, and non-science majors in their "attitude toward science" and "high school science activity." Influences on the choice of major field from within the family were significantly different for pure science, applied science, and non-science majors. These three major field groups did not differ significantly on influences in the high school or in college on choice of major field.

Science majors with cumulative grade point averages of 3.00 and above were found to have a more favorable attitude toward science than non-science majors with comparable grade point averages. The three measures of influence on choice of major field were found to have a relatively strong interrelationship. The subjects comprising the sample, regardless of major field, tended to be the youngest among six children.

The importance of academic ability and achievement and attitude toward science are re-emphasized in choice of science vocations. The effect of influence in high school, the family, and the college on the choice of major field is important to persons in those institutions and those allied with them.

SPATIAL COGNITION, A SUCCESS PROGNOSTICATOR IN COLLEGE SCIENCE COURSES

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This investigation studied the relationship between ability of students to conceptualize three dimensional models from two dimensional diagrams and their success in college science courses. Three hypotheses were tested: (1) Is there a significant difference in spatial conceptualization between science-oriented and nonscience-oriented college students? (2) Does the level of ability to conceptualize three dimensionally differ among students electing majors in the science disciplines? (3) Is there a significant correlation between spatial conceptualization test scores and quality points earned in college science courses among science majors?

The confidence level set for rejection of the null hypothesis was a = 0.05.

Subjects participating in the study were members of intact groups selected at random from the following departments: Physics, Biology, Geoscience, Chemistry, and General Science. Sample size of nonscience-oriented students (enrolled in general science courses) was 57. Sample size of science-oriented students was 89, distributed as follows: Physics - 17, Biology - 44, Chemistry - 17, and Geoscience - 11.

All subjects were administered the SURVEY OF OBJECT VISUALIZATION (SOV), a 44-item instrument devised by Daniel R. Miller: it is designed to measure examinee's aptitude to visualize an object when the object is disassembled and in various positions.

Testing the first hypothesis, an analysis of variance of SOV scores shows a significant difference at the .05 level between the science and nonscience majors in 3-D conceptualization. The mean of the nonscience group was 24.49, with a standard deviation of 9.99. Science majors tested had a mean of 29.63, and a standard deviation of 8.55. The F-value of 10.99 exceeds the critical point of 3.88 required for rejection of null hypothesis.

Testing the second hypothesis related to levels of ability in 3-D conceptualization, results show physics students possessed the highest level (mean - 37.18, S.D. - 5.45). Geoscience majors had a mean of 29.55, a standard deviation of 7.95. Mean of the biology students was 27.96, with a standard deviation of 7.53. The chemistry majors scored lowest among science majors with a mean of 26.47, and a standard deviation of 10.07.

In hypothesis 3, the correlation between SOV scores of each science major and quality points earned in all college science courses completed produced a Pearson product-moment coefficient of $r = 0.51$. Testing the significance of the correlation, $t = 4.6$, the correlation is significant at the .0001 level of confidence.

The educational importance of this study is that:

1. Spatial cognition tests can be used successfully in counseling students considering careers in science.

2. A careful reassessment should be made of the appropriateness of visual aids commonly used in the teaching of science (diagrams, textbook illustrations, slides, transparencies, etc.). The science teacher does not realize how little these aids mean to many students who are incapable of reconstructing in their minds three dimensional models of two dimensional illustrations.

THE DESIGN AND EVALUATION OF AN AUTO-TUTORIAL GENETICS COURSE TO INCREASE SCIENTIFIC LITERACY AMONG NONSCIENCE MAJORS

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The purpose of the study was to design and implement an auto-tutorial genetics course to increase scientific literacy among nonscience majors.

The nonscience major who must take science courses as part of his university education is faced with a dilemma. His background usually does not permit him to complete with a reasonable degree of success the courses offered for science majors. If he is left with no other alternative but to take these courses, the result may be increased frustration, decreased motivation, and even total loss of interest in science itself. On the other hand when courses have been organized specifically for nonscience majors they have often degenerated into mere smatterings of facts or concepts without scientific activity of any kind. There is need, therefore, to develop courses in the contemporary university which will resolve this dilemma. That is, there is need to present to the nonscience major a course that has provisions for the investigation of the relevance and implications of science for man and his world and at the same time is true to the nature of science and the activity of the scientist.

During the fall semester of 1969, students in the genetics course for nonscience majors at Syracuse University were invited to a series of seminars to discuss a redesign of the existing genetics course. Student-instructor collaboration resulted in the selection of six referents to scientific literacy, course objectives, appropriate content, and cross-disciplinary investigations. The objectives of the genetics course redesign, therefore, were consistent with Pella's six referents to scientific literacy. Instructional strategies and content were further modified on the basis of student recommendation, instructor judgment, and the ease and efficiency of achieving the objectives of the course. The instructional strategies selected were auto-tutorial tape sessions, student-initiated panel discussions, and large group lectures. Banathy's procedure for designing instructional systems (1968) was used to establish a time line for developing the course.

There is a central theme for each week of the course and this theme is reflected in a question which a panel of students attempts to answer using as resource material genetics research literature and articles from such publications as Scientific American and Saturday Review. Some of these questions are basic to genetics and others are cross disciplinary in nature. The texts for the course are Facets of Genetics by Srb, Owen, and Edgar (Freeman, 1970) which is a compilation of articles from Scientific American on molecular genetics and Classic Papers in Genetics by Peters (Prentice-Hall, 1959) which consists of articles on classical genetics from genetics journals. Although a set of guide sheets was designed by the instructor for use with the tapes, a paperback entitled Genetics by Winchester (Barnes & Noble, 1961) was recommended for those students who might feel more comfortable with a textbook. The guide sheets for each week contain a bibliography focusing on the weekly theme and the articles which are included in the bibliography may be located either in Facets of Genetics or in Classic Papers or on reserve in the Natural Sciences Library.

A one-hour, auto-tutorial session which precedes the student-initiated panel discussion is used to present the basic concept material needed by the learner as he researches the weekly question. A follow-up session of one hour duration at the end of the week allows the instructor to lecture on unresolved student questions and new developments in genetics pertinent to the weekly theme.

A self-designed, science-related semantic differential instrument will be used to take measures in the affective domain during the academic year, 1970-71. The results of a pilot study of the genetics course for nonscience majors offered at this university indicated that students have negative perceptions in response to such course-related factors as "Interesting", "Valuable", "Easy", "Safe", "Orderly", and "Understandable". The purpose of this course redesign is to help students perceive these course-related factors in a positive way. The purpose of this paper will be to present the results of student-instructor collaboration to develop a plausible, workable, solution to the problem of the lack of courses to increase scientific literacy among nonscience majors.

Session IIb - Science Teacher Education--Pre-service

Chairman: David Lockard, University of Maryland, College Park, Maryland.

1. "Simulating Classroom Reality in the Secondary School Science Methods Course," Paul E. Bell, The Pennsylvania State University, University Park, Pennsylvania.

2. "Change in the Cognitive Preferences of Pre-Service Elementary Teachers," Ronald K. Atwood, University of Kentucky, Lexington, Kentucky.

3. "Problems of Beginning Chemistry Teachers: A Case Study Approach," Edward S. Jenkins, Southern University, Baton Rouge, Louisiana.

4. "Investigation of an Instructional Treatment Designed to Alter Reacting Behaviors of Prospective Secondary Science Teacher," John Jay Rusch, University of Oklahoma, Norman, Oklahoma.

5. "A Study of Selected Outcomes of a Science Pre-Service Teacher Education Project Emphasizing Early Involvement in Schools of Contrasting Environmental Settings," Richard L. Sagness, The University of South Dakota, Vermillion, South Dakota.

6. "A Study of the Relationship Between Science Student Teachers and Cooperation Teachers as Determined by Interaction Analysis," John M. Nickel, Wichita State University, Wichita, Kansas.

SIMULATING CLASSROOM REALITY IN THE SECONDARY SCHOOL SCIENCE METHODS COURSE

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and
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The Pennsylvania State University
University Park, Pennsylvania

Considerable interest regarding the function of the methods course has been shown in the past year. What appears to be needed are (1) analyses of demands being placed on teachers in their teaching assignments, (2) appropriate pre-professional experiences to create competencies that have the potential for meeting those demands, and (3) incorporation of feedback from research data and student teacher supervisors for increasing the viability of the course. Instructors are being asked to provide classroom reality in the preservice courses. The task, then, is one of simulation--the creation of an artificial environment that resembles an actual environment as closely as possible.

The purpose of this paper is to describe an experimental science methods course based upon simulation of selected tasks in teaching science.

A comparison involving specified criteria was made between the experimental course and a more traditionally organized lecture-laboratory course requiring mandatory attendance. The major differences between the two groups were the independent study and systematic observation methods used only by the experimental groups. It seemed likely that students would learn to assert themselves more often if independent study were substituted for the usual three lectures per week. Furthermore, if students were held responsible for conducting a substantial portion of their own instruction, the instructor would be free to use the same amount of student contact time for guiding the student as a unique individual in his pursuit of teaching skills, self-evaluation capabilities, and content organization.

Fifty enrollees for the course were separated randomly into two sections designated as the independent study group and the lecture group. Team teaching and "team conferencing" for both groups was handled by the authors and a graduate teaching assistant.

The experimental course provided student guidelines in the form of behavioral objectives which denoted specific criteria for mastery. Conditions for demonstrating competency were specified by the instructor; students selected the means for developing the competencies and paced themselves according to their own capabilities by contrasting their own requirement deadlines. There were no formal class meetings after the first two weeks of the ten-week term except for the final examination. The most demanding requirement involved the student in videotaping, coding, and critiquing two teaching performances. Coding was accomplished with the Social Substantive Schedule, which was designed to assess and communicate the idea of congruence between a stated objective and a teacher's choice of verbal behavior.

Students also operated all machines, scheduled peers to serve as pupils for their teaching episodes, and initiated requests for special seminars or activities. The mastery model (i.e., resubmit requirements until criteria are met) was applied to both the experimental and control groups.

Informational input was provided through hand-outs, including a glossary of working definitions, readings, and audio-tutorial modules. Thus, most of the instructor's time was reserved for conferences initiated by students and for evaluating written work. Instructional marginal notes were employed liberally.

The control group met for three required lectures and one required three period laboratory per week for ten weeks. Control students completed the same requirements, but guidelines and means for meeting the guidelines were presented in the lectures in a lock-step fashion. Criteria for evaluating the simulated teaching performances were not based upon any systematic observation scheme. Scheduling of organizational details was completed by the instructor.

Analysis of variance was computed for the scores on a knowledge examination, the Test on Understanding Science, and the Course Attitude Questionnaire. Non-parametric analysis was made of the relative number of recycled assignments, assignment quality, submission dates, amount of conference time utilized, and the types of criteria used for videotape critiques. Subsequent student teaching performances will be observed for verbal behavior, types of pupil activities executed, and the types of instructional objectives listed in lesson plans.

CHANGE IN THE COGNITIVE PREFERENCES OF PRE-SERVICE ELEMENTARY TEACHERS

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Little attention has been given to teacher education strategies for preparing teachers to use a cognitive style consistent with the objectives of the new curricula or with the evaluation of such strategies. Assuming that a shift in cognitive style from memory of factual information toward the application and questioning of information is desirable, the question of whether a component of a teacher education program produces a measurable shift appears important. In attacking this question the following hypotheses were tested for a group of 201 students enrolled in a pre-service elementary teacher education program:

1. The mean application cognitive preference score will be significantly greater (.05 level) at the end of the semester.

2. The mean memory cognitive preference score will be significantly less (.05 level) at the end of the semester.

3. The mean questioning cognitive preference score will be significantly greater (.05 level) at the end of the semester.

The students were enrolled in a variety of course patterns with only an inquiry-oriented science and social science methods course common to all schedules.

The Cognitive Preference Examination - II (CPE-II) was used to measure cognitive style in the study, and the hypotheses were stated in terms of the cognitive preferences which the test measures. Pre- and post-means were determined for the preferences (memory, application, and questioning) and one-tailed t-tests were utilized to compare the means.

The t-tests revealed a significantly decreased memory mean and a significantly increased application mean. The direction of change for the questioning mean was as expected but not significant at the .05 level. Hypotheses 1 and 2 were accepted and hypothesis 3 was not accepted.

The primary value of the results lies in the knowledge that cognitive style can be changed in a semester interval and that change can be measured. The relative effectiveness of various instructional strategies and curricular components remains to be investigated.

PROBLEMS OF BEGINNING CHEMISTRY TEACHERS:

A CASE STUDY APPROACH

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The beginning teacher is faced with the complex task of translating theory, learned in college, to the arena of real problems, issues and people in the classroom but also in the school as a whole and the school community. In the early stages of teaching the new teacher would almost certainly face "reality perceptions," meaning a new view of what school is like. In the time interval since the new teacher graduated from high school, he has matured, and has been influenced by the interplay of people and academics of the college campus. Also the high school itself has undergone changes. So "reality perceptions," as used in this study, refer to unanticipated or vaguely considered human and physical realities, which became more real and clearly defined to these young people once they assume the role of teachers. When these perceptions became so strong as to warrant special denotation, the term "reality shock" came into use.

The purpose of this study then was to look into "reality perceptions and shocks" as they developed for five new chemistry teachers, and also to identify those perceptions and resultant adjustments and maladjustments which were distinctive to individual teachers and those which were common to all five.

Five subjects, two females and three males, all seniors, and all chemistry majors were enrolled in the Teacher Education Curriculum at the University of Illinois during the Spring Semester, 1969. To ascertain those encounters judged by these five young people as "reality perceptions and shocks," interview sessions, which were audio-taped, were held with them during the following periods: (1) a seven-weeks period when they taught "mini-classes" in chemistry to University High School students and (2) six-weeks when they performed as student teachers in Illinois public schools. These taped interviews were later transcribed directly. Because the sessions were typically unstructured, the information was arbitrarily classified for clearer presentation.

The new teachers did indeed encounter "reality perceptions and shocks," as was predicted, but many of these perceptions were not specific to chemistry or even to science. The publicly observable phenomena which led to physical and emotional alertness and sometimes disorientations within the new teachers were (1) principally of physical characteristics, inclusive of inanimate objects, buildings, furniture, apparatus and supplies as well as physiological stresses and (2) distinctly human, i.e., thoughts, emotions and other behavior characteristic of people. Those "reality perceptions and shocks" classified principally as physical characteristics produced varying measures of stress and disorientations but were usually satisfactorily coped with in time. Those classified as distinctly human were most likely to produce anxieties and therefore more difficult to deal with.

Especially noted was their feeling of rejection by college chemistry professors, their disappointment over observed "unprofessional" behavior of experienced teachers, the difficulties encountered in attempting to implement aims of the new chemistry curricula, and the trauma which sometimes followed sharp personality conflicts between teacher and students in the classroom.

There was nothing in this study to suggest a set of skills and knowledge existential to all needs to be taught to the prospective teacher in college. Rather, it appeared that more coordinated efforts should be made by educators and chemists to prepare these young people in terms of overall competence, confidence and flexibility so they will be better prepared to react to "reality perceptions and shocks" which they are almost certain to face in the classroom.

INVESTIGATION OF AN INSTRUCTIONAL TREATMENT DESIGNED TO ALTER REACTING BEHAVIORS OF PROSPECTIVE SECONDARY SCIENCE TEACHERS

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The purpose of the investigation was to develop an instructional procedure to give prospective secondary science teachers alternative verbal behaviors which could be used in lieu of rating behaviors, and to measure its effectiveness by analyzing the rating and accepting behaviors of the subjects prior to instruction, after instruction, and the following semester during student teaching. Among the questions asked were: Do the number of acceptance and rating behaviors used by subjects in peer teaching situations change following instruction? Do the number of acceptance and rating behaviors used by subjects during student teaching differ from the number of acceptance and rating behaviors they used prior to, and after instruction? Does the membership of a subject in a specific science methods laboratory section cause a difference in his rating or acceptance behaviors? Does the length of time between instruction and student teaching have an effect on the rating or acceptance behaviors of subjects?

The data used in the investigations were taken from 15 minute audio tapes of science lessons which each subject presented to his (1) peers in the science methods laboratory before instruction, (2) peers in the laboratory three weeks after instruction, and (3) science students in student teaching classes the following semester. Each of the tapes from the 54 subjects in the study was analyzed for the occurrence of rating and acceptance behaviors. Data were collected in five categories: (1) minimal reinforcement (positive ratings presented in understated expressions such as "O.K.," "All right," etc.), (2) praise, (3) acceptance (nonjudgmental statements following student statements), (4) rejection (negative ratings), and (5) all reinforcement-acceptance pairs.

Students were blocked on four levels of laboratory section, two levels of quarter of student teaching, and three repeated measures of tests. Each of the five categories and a sixth category, all rating behaviors (the sum of categories 1, 2, and 4), was scored and subjected to a 2 x 3 x 4 factorial analysis of variance with repeated measures, corrected for unequal cell size Significant differences between tests were further analyzed by use of the t test for correlated means.

The use of minimal reinforcement, rejection, and all rating behavior was not significantly affected by instruction. There was a significant increase in the use of acceptance behaviors during student teaching. A significant decrease in the use of praise occurred which persisted into student teaching. A significant decrease in the use of reinforcement-acceptance pairs occurred, but was lost and a significant increase in this behavior occurred between the methods course and student teaching. Rejection behavior increased when subjects taught actual students and increased as a function of time between the methods course and student teaching. A retention loss as a function of time occurred in the decreased use of praise. Much reinforcement behavior presently used appears to be reflexive rather than intentional. Studies should be conducted to determine how verbal behavioral models become learned behavior. The usefulness of praise in causing cognitive and affective changes is an hypothesis which should be tested at all grade levels and compared to the usefulness of acceptance behaviors.

A STUDY OF SELECTED OUTCOMES OF A SCIENCE PRE-SERVICE TEACHER EDUCATION PROJECT EMPHASIZING EARLY INVOLVEMENT IN SCHOOLS OF CONTRASTING ENVIRONMENTAL SETTINGS

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and

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and
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Selected outcomes of two pre-service teacher education programs in secondary school science education at The Ohio State University were assessed. One program (project) emphasized classroom participation in schools of two environmental settings (urban and suburban) previous to student teaching. Student teaching also occurred in two schools of contrasting environmental settings. The other program (non-project) was developed around methods courses and other university-based courses with few participatory experiences in the public schools previous to student teaching which was done in one school. The sample was comprised of pre-service teachers in secondary (7-12) science education. They were enrolled in the first professional quarter (N = 64) immediately preceding student teaching, or in the student teaching quarter (N = 34).

The selected outcomes (criterion variables) were the pre-service teachers' views of activities which should be used for science instruction in an "urban" setting, those which should be used for a "suburban" setting, the activities the pre-service teachers used for instruction during student teaching, and pre-service teachers' compatibility to work in culturally deprived schools. The compatibility variable was subdivided into two factors (1) attitudes toward culturally deprived students, and (2) knowledge of culturally deprived students. The relationship of selected pre-service teacher variables and, where applicable, cooperating teacher, classroom student, and administrative variables to selected outcomes were also measured.

The instruments used were the Science Classroom Activities Checklist: Teacher Perceptions (SCACL:TP), the Science Classroom Activities Checklist: Student Perceptions (SCACL:SP), and the Cultural Attitude Inventory (CAI). Measures on these variables, with the exception of activities used during student teaching, were taken prior to and at the completion of the pre-service teachers' first professional quarter and also pre- and post-student teaching. The activities which student teachers used for instruction were measured, by means of classroom student checklist responses, near the end of the student teaching experience. Other student teaching data were collected using questionnaires.

Some conclusions were (1) project participants had significantly greater knowledge of culturally deprived students at the end of the first professional quarter than did non-project participants, (2) project student teachers held less positive views of culturally deprived students and of the types of activities which should be used for science instruction in an urban setting at the completion of the student teaching experience than did non-project participants, (3) project student teachers used significantly fewer of the types of activities thought to positively implement the general objectives of science education than did non-project student teachers, and (4) the major influence on the activities used by student teachers for science instruction during student teaching was the cooperating teacher. Relationships are also indicated which provide insight into criteria that might be employed in the selection of schools and cooperating teachers for student teacher placement. Recommendations are made for program revisions and further research.

A STUDY OF THE RELATIONSHIP BETWEEN SCIENCE STUDENT TEACHERS AND COOPERATING TEACHERS AS DETERMINED BY INTERACTION ANALYSIS

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The purposes of this study were: (1) to determine certain changes in classroom verbal behaviors of secondary school science student teachers during the student teaching experience and the relationship of the behaviors of their respective cooperating teachers to these changes, and (2) to identify the relationship between perception of the student teacher by science students in the classroom and the observed verbal behavior of the student teachers.

Twenty-three student teachers in secondary science and their cooperating teachers were observed and their verbal interaction encoded using the Verbal Interaction Category System. The student teachers were observed for thirty to sixty minutes per observation on three occasions: once in the first two weeks (Phase I), once during the fourth and fifth weeks (Phase II), and once during the seventh and eighth weeks (Phase III) of an eight-week student teaching period.

Two observations of thirty to sixty minutes for each of twenty-three cooperating teachers, gathered prior to the time the student teachers taught the same group of students, provided the data for Verbal Interaction Category System analysis. This analysis, pooled into one total matrix, served as a basis of comparison with the verbal behavior of the student teachers.

The Michigan Student Questionnaire was administered during the final two weeks of the student teaching period, to provide an assessment of student attitudes toward the student teacher and the school work.

Based on twelve selected variables of verbal interaction, the following results were identified. (1) There was no significant correlation as determined by the Spearman Rank correlation coefficient between the Phase I and Phase III verbal interactions of the student teachers and the overall verbal interaction of the cooperating teacher on nine of the twelve verbal interaction variables. (2) The variables which were significant in Phases I and III were not the same variables. (3) There was a significant correlation as determined by the Spearman Rank Correlation Coefficient between the Phase II verbal interaction of the student teachers and the overall verbal interaction of their cooperating teachers on eleven of the twelve verbal interaction variables. (4) There was no significant relationship as determined by the Wilcoxon Signed Ranks Test between the science students' assessment of the attitudes toward both the student teacher and the school work and observed verbal interaction of the student teachers.

The present study served to clarify the relationship between student teachers and cooperating teachers in regard to the emulation of the experienced teacher by the novice teacher. The results of this study suggest the need for teacher training institutions to further expand the role of the cooperating teacher in shaping the behavior of the student teacher.

Session IIc - Junior High Science--Including Process Learning

Chairman: Shirley Young, Ferris State College, Big Rapids, Michigan

1. "The Effects of Two Seventh Grade Science Programs on Student Attitude, Science Processes, and Critical Thinking," Donald J. Gudaitis, Westfield Public Schools, Westfield, New Jersey.
2. "A Comparison of the Performance of Seventh-Grade Students With and Without Prior Knowledge of the Objectives of an Individualized Science Program," Betsy A. Conlon, and Ernest Burkman, The Florida State University, Tallahasse, Florida.
3. "An Information Theoretic Interpretation of Science Interaction Dialogues," Gene W. Moser, Willard W. Korth, and Barbara Felen, University of Pittsburgh, Pittsburgh, Pennsylvania.
4. "A Study of the Relationship Between Measures of Teacher-Pupil Verbal Interaction and Students Assessment of Classroom Practices," Willard W. Korth, Jean Czeler, and Gene W. Moser, University of Pittsburgh, Pittsburgh, Pennsylvania.
5. "A Comparison of Programed and Conventional Instruction in Life Science When Graded to Reading Level of Junior High Underachievers," William R. Fryar, The University of Florida, Jacksonville, Florida.
6. "The Process Learning Components of Introductory Physical Science: A Pilot Study," John W. Butzow, University of Maine, Orono, Maine, and Leyton E. Sewell, Bangor State Hospital, Bangor, Maine.

THE EFFECTS OF TWO SEVENTH GRADE SCIENCE PROGRAMS ON STUDENT ATTITUDE, SCIENCE PROCESSES, AND CRITICAL THINKING

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Westfield, New Jersey

This study compared two seventh grade science programs, Interaction of Man and the Biosphere (IMB) (experimental) and Science is Explaining (control) on development of student attitude, science process skills, and critical thinking ability. The study population included two teachers and their eight classes from two suburban New Jersey junior high schools. Each teacher had two experimental and two control classes. The control group consisted of 48 boys and 48 girls. The experimental group consisted of 48 boys and 48 girls. Students were assigned to their classes by computer. Instruments used were Attitude Toward Any School Subject for attitudes toward science; Test of Science Processes for science process skills; and Cornell Test of Critical Thinking--Level X for critical thinking ability. All tests were administered in September/October and readministered in late April/May.

To insure that data were not contaminated by differences in I.Q. and sex of students, an analysis of variance was computed for four groups: control male, control female, experimental male, and experimental female. There were no significant differences in ability (Otis Lennon Test) among the four groups.

Data were subjected to analysis by use of a two-tailed correlated t test to measure the amount of mean gain from pretest to posttest for experimental and control programs. The mean differences between the experimental and control program were tested by a two-tailed t test at the .05 level.

From pretest to posttest on attitude toward science, the experimental program showed no significant attitude change; the control program showed a significant decrease in attitude with no significant difference in mean difference scores between the two programs. For science process skills, the mean gain scores in both programs showed significant growth, with no significant difference in mean difference scores of the two programs. For critical thinking ability, mean gain scores for both programs showed significant growth. Students in the experimental group made significantly greater gains in critical thinking ability than students in the control group.

IMB apparently offers junior high school teachers an inquiry based program that improves critical thinking ability, science process skills, and helps maintain positive student attitude toward science.

A COMPARISON OF THE PERFORMANCE OF SEVENTH-GRADE STUDENTS WITH AND WITHOUT PRIOR KNOWLEDGE OF THE OBJECTIVES OF AN INDIVIDUALIZED SCIENCE PROGRAM

Besty Ann Conlon
and
Ernest Burkman
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This investigation was conducted to determine if providing seventh-grade students with the objectives of instruction altered their performance as compared to seventh-grade students not provided with the objectives. Chapters one through eight of the 1968 grade seven materials produced by the Intermediate Science Curriculum Study (ISCS) were used in this study. Two treatment groups were selected from the 1968-69 ISCS field trial. The sample was all seventh-grade students taught by four teachers. The students of two of these teachers received objectives prior to the study of each chapter. The students of the remaining two teachers did not receive objectives. All students were given a pre- and posttest composed of selected ISCS achievement test items. The items were based on the objectives for the chapters used in the study. Upon completing a chapter, all students took chapter self-tests also based on the objectives.

For purposes of the analysis, each student was categorized into one of three ability levels (high, middle and low) according to his score on the California Test of Mental Maturity (CTMM). It was hypothesized that knowledge of the objectives would not advantageously alter student performance on either the achievement test or the chapter self-tests. In addition, it was hypothesized that knowledge of objectives would not have different effects on students of high, middle, and low ability.

The data were analyzed using analysis of variance. In this study the experimental unit was all the classrooms under the same teacher. That is, although each teacher taught more than one class of grade seven ISCS materials, the different classrooms of each teacher were treated as if they were "one classroom." Each ability level within this "one classroom" was treated as a repeated measure of the "individual classroom."

The results of the study indicated that although the grade seven ISCS students with prior knowledge of the objectives of instruction performed slightly higher than the students without knowledge of the objectives, the difference was not significant at the .05 level. The main effect of CTMM level was statistically significant at the .05 level. There were no significant interaction effects between ability level and treatment. Within the limitations of this study the findings challenge the premise that knowledge of objectives for a highly structured instructional sequence such as ISCS significantly alters student performance.

AN INFORMATION THEORETIC INTERPRETATION OF SCIENCE INTERACTION DIALOGUES

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and
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Interaction dialogues in science classrooms have variety, consist of chains of dependent messages, and exhibit stochastic processes. Having these characteristics, such dialogues may then satisfy the theorems of information theory. The problem was to determine the applicability of Information Theory to interaction dialogues and the consequent meanings.

Thirty class periods of "verbal" communications in junior high school science classrooms were interaction analyzed. These were collected from classrooms of three types of science teaching and represented a diversity of science teaching practices. The category system used for interaction analysis was one modified from that developed by Parakh. The 30 interaction dialogues, consisting of an average of 476 codes (in digram and trigram message forms) were each converted into a probability matrix of joint messages. The matrices were then treated (on a 360/500 IBM computer) by driving them to higher powers (to a power limit of 65,360) until they reached steady states.

The interaction dialogue matrices were found to be irreducible chains; usually with a defineable steady state and stationary distribution. The conclusion was that the dialogues are relatively typical Markovian Chains. Matrix powers at which steady state was reached were found to be quite related to the characteristics of the dialogue. The cell probabilities of joint message codes oscillated as power levels were increased but characteristically converged to stationary distributions. These findings permitted the use of a principle of dependence of joint messages for assigning the meaning of structural coherence to the original dialogue. Thus, a relationship was established between the single and joint messages of the dialogues.

Several information measures were used in developing the relationship between Information Theory and interaction analysis: H_A, H_{max}, relative entropy, and redundancy. The measures were applied to unconstrained and constrained dialogue matrices and it was found that measure values were related to the linkage conditions. The information measure values were found to approximate those determined by other researchers in their treatment of languages. Dialogue redundancy values ranged from 12 to 70 percent for the original dialogue and the constraint levels at steady state.

It was concluded that science interaction dialogues can be interpreted with Information Theory. The use of Markovian Chains offers a means to do comparative studies of the structure and coherence of science classroom dialogues.

A STUDY OF THE RELATIONSHIP BETWEEN MEASURES OF TEACHER-PUPIL VERBAL INTERACTION AND STUDENTS ASSESSMENT OF CLASSROOM PRACTICES

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and
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In recent years there has been a trend in science education to emphasize investigation and inquiry as means of acquiring significant knowledge and skills in science. There are two important components to any science classroom using this approach: (1) students engage in activities which stress the investigative nature of science, and (2) the role of the teacher changes from that of a source of information to that of a resource and guide to facilitate the acquisition of knowledge by students through investigative procedures.

Verbal behavior involves the exchange of ideas between the teacher and pupil and between pupils themselves in the classroom. If verbal communication encompasses a free exchange of ideas between individuals, this flow of ideas constitutes one aspect of the inquiry situation. Thus measuring the amount and type of interaction can be thought of as a potential measure of the investigative nature of a classroom. This study investigated some of the relationships between measures of the nature and quantity of verbal interaction and the type of activities found in the science classroom.

Ten science classes were randomly selected from the classes of 42 junior high school science teachers enrolled in an in-service program in earth science at the University of Pittsburgh. Each class was audio-taped and then analyzed using a modified form of the Parakh Interaction Analysis System. In addition, a modified form of Kochendorfer's Biology Classroom Activities Checklist was administered to the students in each of the classes. Each teacher also completed a questionnaire describing the characteristics of the class and the nature of the science course. Measures of certain features of the classroom verbal interaction were then correlated with both the total score and the scores on the sections of the Classroom Activities Checklist.

The mean amount of teacher-talk for the 10 classrooms was found to be 80.8 percent (range from 64.3 percent - 97.3 percent) with a standard deviation of 9.7 percent. The scores on the Kochendorfer Inventory ranged from 23.3 to 33.5 points (using the class average) out of a possible 55 points. The mean score for all classes was 27.5 with a standard deviation of 3.3.

Teacher statements averaged 61.2 percent of the verbal communications while teacher questions made up 19.2 percent. Pupil self initiated statements (statements not directly solicited by the teacher) made up less than 4 percent of the total dialogue. The average amount of time spent in the lecture mode across all classes was 64.9 percent.

Spearman rank correlation coefficients were calculated for various interaction measures and results from the classroom Activities Checklist. A rank correlation of -.79 was found for measures of the percent of time spent in teacher talk and total scores on the Activities Checklist. However, when the percentage of time spent on teacher questions was correlated with total scores on the checklist, the rank correlation coefficient was found to be +.90. These findings suggest that the verbal behavior patterns in the classroom are related to the teacher's orientation towards student investigative activities and that the assessment of these two components provides a mechanism for evaluating the extent to which inquiry is being utilized.

A COMPARISON OF PROGRAMED AND CONVENTIONAL INSTRUCTION IN LIFE SCIENCE WHEN GRADED TO READING LEVEL OF JUNIOR HIGH UNDERACHIEVERS

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It was the purpose of this study (1) to reduce five "reading activities" in a seventh grade life science unit from seventh to fourth grade reading level, the approximate reading level of the population of underachievers using the materials, and to compare achievement on author-constructed tests of students receiving the graded materials to those receiving the materials as originally written and (2) to convert the original reading activities to illustrated pencil and paper programed instruction with no higher than a fourth grade reading level and to compare achievement, as above, of students receiving the graded materials presented in programed form to that of students receiving the materials graded to reading level but in conventional form.

This study took place in Jacksonville (Duval County), Florida, and involved 240 students in 8 seventh grade classes in 4 junior high schools. An "underachiever" was defined as a student having average or above average intelligence as measured by the Kuhlmann-Anderson Test (Form D) but ranking in or near the 30th percentile, nationally, in four subject areas of the Intermediate II Battery of the Stanford Achievement Test.

Subjects were randomly assigned to experimental or control classes in each of the schools. Teacher assignment was also by random means. Each of the experimental groups was further divided, randomly, into those students receiving the graded prose materials and those receiving the graded programed materials. Achievement comparisons were made between groups receiving graded prose and those receiving ungraded prose.

The pretests which were administered before each of the five activities were constructed by the author and their content was determined to be valid. Reliability of the pretests was established by means of a pilot study on a similar population of students, and the pretests were used, in the same form, as posttests. Initial inadequacies of the programed material were uncovered by one-to-one and small group testing.

Final results were analyzed using multiple linear regression equations and will be reported. It is anticipated that this study will demonstrate the increased effectiveness of programed instruction over conventional reading activities when emphasis is placed on matching the reading level of the materials to the reading level of the junior high underachievers who receive them.

THE PROCESS LEARNING COMPONENTS OF INTRODUCTORY PHYSICAL SCIENCE: PILOT STUDY

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Many science educators have written and commented about the possible process learning components of the recently developed project courses. It would appear from watching junior high school students participate in the type of direct learning activities described by the IPS program that a major change could occur in their abilities to observe, to measure, to infer, to use and collect numerical data, to communicate with graphs, and to design parts of laboratory investigations. The first five chapters of IPS seemed especially geared to the development of such process skills or at least to their being adequately practical at the junior high school.

This project was conducted in order to determine if process learning was significantly changed during the period of time that eighth grade students were using the first five chapters of IPS. The sample consisted of the eighth grade classes which used IPS during the fall of 1969 at Union Street Junior High School located at Bangor, Maine. Classes were organized on a homogeneous basis. Divisions were labeled 8-1 through 8-5 from high to low. About 79 students participated in this study. Criteria for placement included I.Q., teacher recommendations, interviews conducted by guidance personnel, and student records of achievement in English and mathematics. These classes were taught by one of the authors who served as an interclass control. At the time he had taught IPS for two years and had completed training at an IPS sponsored workshop.

The experimental data gathering procedures consisted in administration of the Test of Science Processes (TSP) which was developed and field tested for the junior high school by R. S. Tannenbaum (1969). This test was administered prior to any IPS instruction and also after all classes had completed chapter five of IPS. In addition, three process practical examinations developed by the authors were administered following chapter numbers two, three, and five.

The basic statistical hypothesis was that there would be no statistically significant changes in process learning skills during the time period selected. The 0.05 level of confidence on t tests for each class studied separately as well as the entire eighth grade on the Process test scores was the procedure employed. The null hypothesis was not rejected. For most of the process sub-tests of TSP the mean scores for each class were identical on a pre-post basis. Such data hardly warranted more sophisticated analysis.

The classes were compared on their scores on the author developed practical process measures to determine if certain IPS chapters facilitated the development of specific skills. In general, the scores indicated a positive correlation between placement into homogeneous groups and process scores. One notable exception was skill in using the balance beam in which all groups produced like scores.

The data trends available from this study were disappointing particularly because significant positive changes in measured process skills were not observed. Obviously, this could be due to the use of a pencil and paper test as the primary data gathering device. It could be, however, that process learning is more appropriate to elementary school. It should be noted that scores on TSP were fairly normally distributed about a mean of 52 out of a possible 96. The authors suggest, moreover, that as others replicate studies of this sort, science educators may be able to evaluate the process learning construct as myth or reality.

Session IId - Special Reports

Chairman: Gladys Kleinman, Jersey City State College, Jersey City, New Jersey.

1. "Interdisciplinary Approaches to Chemistry: A Cooperative Effort," Marjorie Gardner, University of Maryland, College Park, Maryland.
2. "Structure: For the Preparation of Junior High School Science Teachers," Bernard E. Michals, California State College, Bakersfield, California.
3. "Aid to In-Service Teachers: A Case Study of a Field Trip and Guides to Selected Field Sites for the Teaching of Earth Science," Felicia E. West, University of Florida, Gainesville, Florida.
4. "A Study of the Three Year Unified Science Program in Millburn Senior High School," Leonard C. Blessing, Millburn Senior High School, Millburn, New Jersey.
5. "Seek-It: A Student Directed Study About Drug Abuse," William B. Shell, Auburn University, Auburn, Alabama.

INTERDISCIPLINARY APPROACHES TO CHEMISTRY:

A COOPERATIVE EFFORT

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When high school and college chemistry teachers work together, good things happen. This has been demonstrated in the past through the development of science curricula such as CHEM Study, CBA, IPS, PSSC, and PSNS. It has been demonstrated even more clearly through the Chemistry Teaching Associate program at the University of Maryland which brings high school and college teachers together into a productive team relationship. If new curricula can be produced by a small number of high school and college people working together in a writing conference isolated from ordinary responsibilities as was the case in the development of CHEM Study and CBA, then perhaps an even better curriculum can result if the high school teachers and college professors work together to develop a new program in the context of the actual academic year.

A new program is underway at the University of Maryland to test this hypothesis. Fifteen members of the chemistry faculty have joined with the Teaching Associates and approximately 30 high school teachers to produce a new high school chemistry course. This course, Introductory Approaches to Chemistry (IAC), consists of eight interchangeable instructional units. Among their characteristics are a high level of investigative activities, an inquiry approach to learning, interdisciplinary themes, flexibility and individualization, and a return to science interest and relevancy in high school chemistry. An attempt to achieve these goals is being made through development of instructional units in basic chemistry, inorganic chemistry, organic chemistry, biochemistry, nuclear and astrochemistry, geo and cosmo chemistry, environmental chemistry, and physical chemistry. Other units can be added as the project develops. A demonstration program and media packages are being prepared. The course is being taught in its first draft form, to approximately 40 high school teachers in an in-service institute. While the chemistry professor focuses his attention on appropriate laboratory activities in developing the content themes the participants in the program are also involved in the development of the curriculum through the identification of performance objectives, statements of concepts, construction of evaluation items, and critical feedback in regard to all activities and ideas. While the course is being taught to local teachers this academic year, it will be taught to teachers and resource personnel from other areas of the country during the summer in an attempt to avoid too parochial a design. The interchangeable units permit this program to be used in conjunction with teaching programs currently in use, to be arranged into a one-semester or full year chemistry program exclusive of the existing programs, to become a second-level chemistry program to follow after the earlier programs, or to become a chemistry course for non-science majors at the junior college level. The design also permits continuous revision and adaptation to local situations and to reflect changing interests of students and the culture.

STRUCTURE: FOR THE PREPARATION OF JUNIOR HIGH SCHOOL SCIENCE TEACHERS

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The purpose of this study was to design behavioral constructs for the preparation of junior high school science teachers. The procedure for this purpose was based on: (1) concepts by intuition through history, observation, teaching experience; (2) concepts by postulation designated by factual data; and (3) epistemic correlation.

Science is bodies of knowledge accumulated by different processes of inquiry. These processes identify junior high school science teaching[a], combined with certain psychological aspects of early adolescents[b], and current practices of junior high school science teachers[c]. Collection and interpretation of complex data on (a,b,c) make up stage I of this study. Inspection of relevant facts designated by problem analysis in stage I form the second stage of inquiry. The relations which exist in the first stage (a,b,c) designate concepts by postulation which are in part sensed and in part imagined. It is precisely this means by which scientific objects have been determined to exist theoretically and have been confirmed later through experimentation. Concepts by postulation about the qualities of junior high school science teaching form the structure of teacher education and have no relationship to the number of preservice credit hours and the reorganization of the junior high school.

Observable and non-observable relations exist between intuitive concepts a,b,c; and are therefore concepts by postulation. Since this type of concept differs from immediately apprehended facts, not all of them can be verified directly. However, they can be stated in terms of their deductive consequences. To connect unobservable factors designated by concepts by postulation to observable data denoted by concepts by intuition, requires a deductively formulated theory. This relation is not identical but instead the relation of epistemic correlation.

The result includes eighteen postulates for junior high school science teaching that are stated together to form the teacher education structure for the preparation of junior high science teachers.

Investigations to construct the teacher competencies are essential for the improvement of junior high school science teaching. Using the behavioral constructs based on the theoretical foundation of this study could provide educators with the structure for setting up experiments and the assessment of outcomes.

AID TO IN-SERVICE TEACHERS: A CASE STUDY OF A FIELD TRIP AND GUIDES TO SELECTED FIELD SITES FOR THE TEACHING OF EARTH SCIENCE

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The changing atmosphere in the world of education and the deteriorating condition of the atmosphere, lithosphere, and the hydrosphere of our planet have brought about many innovations in our science curricula and our methods of teaching. It is within this realm of changing 'spheres' that field studies or field trips can move to a position of new meaning and importance as a most effective teaching technique.

Due to the lack of quantitative research the assumption must be made that the field study or field trip is an effective and valuable teaching technique. The basic need for this study became apparent when it was recognized and admitted that many teachers, lacking sufficient training, information, and confidence hesitate to use the natural environment in the teaching of earth science. Given encouragement through detailed directions and field trip guides, many in-service teachers, who might otherwise shun such an approach to teaching, may come to make use of its potential.

The purpose of the study was to develop a case study of a field trip to serve as a model for teachers unfamiliar with the use of field studies as a technique of teaching, and to develop a set of guides to serve as a model for those teachers wishing to make a survey of available sites in their area.

The case study shows how one should go about locating sites for possible field studies, investigating these sites, imterpreting the observations, planning the study, making visual aids (slides), planning for student involvement in classroom activities prior to and following the trip, and revising the plan for the study based on student, teacher and geologist evaluations. Additional sites were explored, observed and interpreted with the assistance of resource people when needed. Field guides have made available to many teachers some knowledge of the experts in botany, geology, etc.

This study served as a doctoral dissertation for the author and will serve as a basis for further investigation into the use of field studies as a teaching technique. A research proposal is now being developed which will seek to evaluate the worthiness of this technique using the field guides developed in this study. The research will be conducted at the P. K. Yonge Laboratory School and, as funding becomes available, will be extended to selected schools in the surrounding counties. The results of the research should influence educators and teacher education institutions to place more emphasis on preparation in the use of this technique or to exert more effort in the development of new and better ways for teaching earth science while at the same time developing the much needed environmental awareness in youngsters.

A STUDY OF THE THREE YEAR UNIFIED SCIENCE PROGRAM IN MILLBURN SENIOR HIGH SCHOOL

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Millburn Senior High School
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Millburn Senior High School introduced a new three year Unified Science course in September, 1967. The course is not designed for any particular level of students, but just for those students who intend to study science for three years. The basic principle in the course was to include as many overlapping and unifying points as possible. Just one example that developed from the course follows:

> In the second unit, one of the concepts studied is density (mass/unit volume). The third unit includes the structures of cells. The usual items of cell structure are observed in onion, elodea, epidermal, and epithelial cells. But here is the difference. The students were instructed to determine the density of an onion cell. This procedure included the use of the Mettler balance, calculations using significant figures and scientific notation, living onion cells, use of the microscope and an answer that was new to all people concerned, even the teacher.

This activity involves an interrelationship between biology, physics, mathematics, and the use of scientific instruments.

It was necessary to devise some testing device to determine if there was any difference in the learning and retention level between the new Unified Science group and those students studying science in other science courses. It was decided to use the Educational Testing Service Cooperative Science Tests in Biology, Physics, and Chemistry, Form B.

The students in the Unified Science class comprised the experimental group. The control group was selected from students enrolled in the regular science courses. The IQ's of the members of the Unified Science group and the control group were recorded, then going down the nearly alphabetical list of names in the control group the first exact matching IQ that was reached was selected to be one of a matched pair (the control student and the Unified Science student). The Unified Science group was given the Cooperative Biology, Chemistry, and Physics tests early in the first year of the course. They did not see the tests again until the end of the third year of the course when they retook the tests as a final exam.

All the regular biology, physics, and chemistry classes took the Cooperative tests on the first day of school at the beginning of their courses and then the same test on the last day of school as a final exam. The students who were selected to be in the control group plus many others took the same test again the first week of June three years after starting the regular biology course.

The instruments used for the comparison, the ETS Cooperative Biology, Physics and Chemistry Tests, Form B, were not constructed to measure concepts specific to a unified science program. But they do measure concepts of biology, physics, and chemistry generally accepted as meaningful in the United States. We do claim that the students after three years of Unified Science as taught in Millburn Senior High School have a deeper understanding of the interrelationship of all areas of science.

The statistics point out that the unified science students have a greater level of retention at the end of their high school careers of all areas of science in the accepted facts and concepts than those who took the more normal science program.

SEEK-IT: A STUDENT DIRECTED STUDY ABOUT DRUG ABUSE

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Seek-It is an acronym for Self-directed Educational Experiences Kit. It utilizes the systems approach to developing units of study that can be used by students on a self-directed basis.

A Seek-It has been created about drug abuse (the physiological, psychological, sociological, and pharmacological aspects). The Seek-It is composed of a teacher guide and a student guide. The teacher guide contains an overview of drug abuse content, a set of concepts of learnable ideas about drug abuse, a set of behavioral or performance objectives, a pretest and posttest, a list of materials that come with the Seek-It, a list of optional materials, and directions for the initiation of the individualized instructional program in the classroom.

The student guide contains an introduction to the student explaining what is expected of him and how he is to proceed. Also included are a list of the learnable ideas, behavioral objectives, the pretest and answer key, and five multi-level, multi-media lessons. Four animated sound filmstrips, five taped interviews with junkies and dealers, and three taped learning tracks are included in the Seek-It.

After the student completes one task, he is told what his next step is or what his options are. This particular Drug Abuse Seek-It has been field tested and revised three times in the past year.

Session IIe - Secondary School Science--Laboratory, Attitudes and Concepts

Chairman: Richard Moore, Miami University, Oxford, Ohio

1. "The Science Support Scale: Its Appropriateness with High School Students," John Shrum, The University of Georgia, Athens, Georgia, and Ronald D. Simpson, The Westminster Schools, Atlanta, Georgia.
2. "A List of Currently Credible Biology Concepts Judged by a National Panel to be Important for Inclusion in K-12 Curricula," Benjamin E. Thompson, Wisconsin State University, Eau Claire, Wisconsin, and Milton O. Pella, University of Wisconsin, Madison, Wisconsin.
3. "A Comparison of Two Methods of Managing Laboratory Experiments," Judy C. Egelston, and Richard L. Egelston, State University of New York, Genesco, New York.
4. "A Comparison of the Success of Various Cultural Groups in the Biological Sciences Curriculum Study (green version) Program at the Lancaster High School," Carl E. Funk, Jr., and H. Seymour Fowler, The Pennsylvania State University, University Park, Pennsylvania.
5. "Extremity-Confidence of Hypotheses and Verbal Discourse as Measures of Student Risk-Taking in Explanation of Biological Events," Jerry G. Horn, University of South Dakota, Vermillion, South Dakota.
6. "The Development and Validation of a Quasi-Nonverbal Test for Measuring Attainment of Relational Concepts in High School Physics," H. Seymour Fowler, The Pennsylvania State University, University Park, Pennsylvania, and Edward F. Podrasky, State College Area School District, State College, Pennsylvania.

THE SCIENCE SUPPORT SCALE:

ITS APPROPRIATENESS WITH HIGH SCHOOL STUDENTS

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and

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The Westminster Schools
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A recent and widely distributed NSTA publication, "Behavioral Objectives in the Affective Domain" by Eiss and Harbeck, contained a scale, the Science Support Scale (Tri-S), for assessing attitudes related to science. This scale, a forty-item Likert-type scale, was designed by Patricia Schwirian. The theoretical orientation of the Tri-S scale was drawn from Bernard Barber's position in Science and the Social Order. Barber suggests that there are five cultural values necessary in a society before science can develop optimally as an enterprise within that society. The Tri-S scale is composed of five subscales which correspond to Barber's five cultural values.

While the aforementioned NSTA publication did not specify how and where the Tri-S scale could be used, the nature of this publication seemed to suggest its use with secondary students. Schwirian originally used the scale with college students but proposed that it might be appropriate for measuring the attitudinal growth of high school students.

The purpose of this report is to look carefully at the appropriateness of the Tri-S scale with high school students based on recent research by the authors of this paper.

All tenth grade biology teachers in a large school system were administered the Tri-S scale. Twenty-four teachers participating in the study were blocked into four equal-sized groups based on comparative Tri-S scores ranging from "high" to "low" support of science. One class of students was randomly selected from each teacher and the Tri-S scale administered to these students at the beginning and end of the year. A total of 618 students were involved in the study.

Student scores resulted in no significant gains from pretest to posttest. These data indicated that the students in this study did not increase in their support of science as measured by the Tri-S scale after eight months of exposure to an introductory high school biology course.

An analysis of covariance was computed for each of the five subscales of the Tri-S and the total score. F-values were not significant at the .05 level for the teacher group variable in four of the five subscales and the total score. In no case did students from teachers scoring "high" in science support score significantly higher than students from teachers "low" in science support. A rank order coefficient of correlation between individual teacher scores and their posttest class means was calculated to be .128.

Reliability estimates were calculated for each subscale and ranged from .338 to .558. These estimates were considerably lower than earlier estimates using college students.

Correlation coefficients were computed between all items of the Tri-S scale. Coefficients resembled that of an identity matrix and factor analysis demonstrated that items within the individual subscales were not interpreted with similar meaning by the students.

Teacher feedback during the study strongly suggested that many words and items in the Tri-S scale were vague and meaningless to high school students.

Evidence from this study strongly suggests that the Tri-S scale is not an appropriate instrument for measuring achievement of high school students in the affective domain. The study further suggests that more data concerning reliability and validity estimates are needed from diverse populations before the scale be considered appropriate in any situation.

A LIST OF CURRENTLY CREDIBLE BIOLOGY CONCEPTS JUDGED BY A NATIONAL PANEL TO BE IMPORTANT FOR INCLUSION IN K-12 CURRICULA

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and

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The primary purpose of this study was to construct a list of currently credible biology concepts judged to be important for inclusion in K-12 curricula by a national panel of biologists, science educators, and high school biology teachers.

An initial list was created by asking a panel composed of University of Wisconsin biologists to list the five to seven most important concepts from their specialty and from biology in general to which a student should be exposed before graduation from high school. The replies were combined to form an Initial List of 151 concepts.

The Wisconsin panel was then asked to assess the Initial List for precision and credibility, making changes where needed, and to judge the importance of these concepts to a K-12 curriculum. The criteria established for inclusion on the Second List were met by 114 of the 151 concepts.

Next a National Panel of 387 biologists, science educators and biology teachers assessed the 114 ammended concepts for their importance to a K-12 curriculum. This panel was also asked to make changes where needed to insure the precision and credibility of the concepts and to add important biology concepts not on the list.

A Final List of the 114 concepts as amended by the National Panel resulted.

Treatment of the data resulting from this study reveals the following:

1. Correlations between each group's rank ordered list of the 114 concepts were:

    A. University biologists and science educators, 0.7078;

    B. Science educators and biology teachers, 0.8009;

    C. University biologists and biology teachers, 0.7696; and

    D. Between all three groups, 0.7594.

2. When ranks assigned to a concept by the three groups were compared it was found that at least two of the three groups agreed within the criteria on the rank assigned to 69 percent of the concepts. All three groups ranked 31 percent of the concepts differently.

3. There was no significant difference at the 0.25 level between the mean scores assigned by the three groups to 62 percent of the concepts. Not one of the 114 concepts was assigned a significantly different mean score by all three groups.

4. Of the 114 concepts listed 19 were considered to lack credibility by 2 percent or more of the panel members.

5. University biologists accounted for 50 percent of the concept modifications, science educators 35 percent of the modifications and biology teachers 15 percent. University biologists and science educators were seen to agree more often on the frequency of modifying a concept than science educators and biology teachers or university biologists and biology teachers.

6. There were 10 concepts considered unclear by 2 percent or more of the university biologists, eight concepts considered unclear by 2 percent or more of the science educators and two concepts considered unclear by 2 percent or more of the biology teachers.

In conclusion, all three groups of the National Panel are similar in their rating and ranking of the 114 biology concepts. University biologists and science educators are more similar in the frequency of making comments and modifying concepts than are science educators and biology teachers or university biologists and biology teachers. The utilization of university scientists was a successful method of creating a current, credible list of biology concepts.

A COMPARISON OF TWO METHODS OF MANAGING LABORATORY EXPERIMENTS

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and
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This study compared two groups of high school biology students with respect to laboratory achievement, learning climate, and laboratory behavior on the part of both students and teachers. A cell physiology and nutrition unit containing ten exercises was utilized by five randomly assigned teachers (eighty-six students) in an open-inductive method and by four randomly assigned teachers (ninety students) in the conventional method. All teachers were experienced, volunteered to participate, and were given a special training session.

A pretest of knowledge concerning cell physiology and cytology was given, and a brief quiz was administered following each exercise. The multivariate analysis of covariance test of equality of mean vectors resulted in a significant difference between the experimental and control groups.

Trend analyses were conducted both by order of administration and by sequence number with and without the pretest covariate. In all trend analyses there were significantly different linear and quadratic components to the set of means. The two groups also differed significantly on the linear interaction component, but there were no significant differences on the quadratic interaction component. The hypotheses that achievement would improve over the span of ten exercises, and that an open-inductive method would result in higher achievement scores were not supported. However, the adjusted trend analysis revealed some evidence that, after several experiments using the inductive method, the hypothesized curvilinear trend in achievement scores of the open-inductive group were equally as good or better than the scores of the control group.

Classroom behavior was obtained by means of an interaction analysis category system developed by the author and collected by trained but "blind" observers. These data were separated into three categories: teacher-pupil interaction data, student data, and teacher data. Kolmogorov-Smirnov tests following Markov chain analysis revealed that the laboratory behavior of the two groups was significantly different on five of six comparisons. The teachers using the open-inductive method were more indirect, while the control group teachers used more direct means of managing the laboratory activities demonstrating construct validity of the category system. Student behavior was significantly more dependent in the control classes.

Classroom climate was assessed with an instrument designed to measure the socio-emotional properties of the learning environment. A multivariate one-way analysis of variance upheld the author's expectations of significant differences between the two groups.

The use of an open-inductive method yielded significantly different results for classroom behavior, for learning environment and for achievement. Taken together these results indicate that a teacher who hopes to foster greater independence in his science students may try using laboratory activities which are written as an open-inductive investigation. He should also use behavior which is indirect, and supervision which is passive during the activity portion of the lab. His basic criterion should not be improved achievement since this may actually be lowered initially, although with practice it might be equal to or possibly surpass the achievement of students who had been in laboratories which were traditionally managed.

A COMPARISON OF THE SUCCESS OF VARIOUS CULTURAL GROUPS IN THE BIOLOGICAL SCIENCES CURRICULUM STUDY (GREEN VERSION) PROGRAM AT THE LANCASTER HIGH SCHOOL

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The problem reported in this paper was to investigate if any statistically significant differences in "success" among various cultural groups were evident within the Biological Sciences Curriculum Study Program (green version) (hereafter referred to as BSCS) at the J.P. McCaskey High School, Lancaster, Pennsylvania. Success was defined as a student's attaining a passing grade of "D" and therefore not being required to reschedule biology at this high school. An "A" grade was defined as "highly successful;" "B" and "C" grades were "average;" and "F" was "unsuccessful." The purpose of the study was to ascertain if the BSCS textbook could be used effectively for all tenth grade students in the Lancaster City School District.

To attack the main problem, and related sub-problems, the authors examined the permanent records of all students involved for both a reading comprehension score and Intelligence Quotient as measured by the Stanford-Binet Test. Research findings were reported with the Stanford-Binet Test when comparing the achievement of all groups, but based on the comparative reading levels as measured by the California Achievement Test in Reading when the achievement of the city groups was compared.

One hundred and ten students made up the sample which was differentiated into three cultural groups as defined by the authors. Two groups were within the city of Lancaster and the other within the surrounding township.

Through statistical analyses of the obtained data, the authors' findings showed statistically significant differences among cultural groups in the success (as defined) of the groups within the program. The sample was shown to have a normal distribution, and t-scores were interpreted with the five percent (5%) level as significant and the one percent (1%) level as highly significant. The reading levels of the two city groups were also found to be statistically different as measured by the California Achievement Test in Reading.

After calculating the approximate reading level of the BSCS text by the Dale-Chall Readability Test and Fry Test for Readability, the author found that the reading level of the textbook was within the range of the students investigated, i.e., the reading level was approximately equal to or lower than the students' achievement (in grade level equivalents) in reading as measured by the California Achievement Test in Reading. Within the program itself, however, there were some cultural biases (as defined) in the BSCS program that were related to reading level alone even though the reading level was applicable to the students' apparent abilities. The relative success of the different cultural groups helped to substantiate the claim.

The educational importance of this study was to, perhaps, alert the district of possible biases within their science education program. In this way some constructive criticism may have been offered for the improvement of the curriculum

EXTREMITY-CONFIDENCE OF HYPOTHESES AND VERBAL DISCOURSE AS MEASURES OF STUDENT RISK-TAKING IN EXPLANATION OF BIOLOGICAL EVENTS

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This study investigated the effect of achievement motivation, group composition for purposes of discussion, status of information about a biological event, IQ and the sex of individuals on the propensity for risk-taking by biology students as they explain an event of biology.

The subjects for this study consisted of 136 high school biology students selected on student, teacher and course characteristics. By random procedures, the subjects were assigned by classes to two knowledge conditions of the status of the information (known and unknown) about the behaviors or events they observed in a filmed sequence of elephant seal activities. The Extremity-Confidence of Hypothesis Test was administered to each subject, and then they were assigned to discussion groups, identified as like-high, like-low or unlike as to the members' measured achievement motivation level. During a ten minute discussion of the two scenes, the students were observed by one judge per group using the Risk-Taking Verbal Observation Scale. At the end of the discussion period, the group submitted a second copy of the Extremity-Confidence of Hypothesis Test containing the group's responses. The groups disbanded, and a third administration of the Extremity-Confidence of Hypothesis Test occurred making a total of two for individuals and one for groups.

The dependent variable, risk-taking as measured by the Extremity-Confidence Hypothesis Test and the Risk-Taking Verbal Observation Scale, was analyzed within 2 x 2 and 2 x 3 factorial designs and a correlational analysis was conducted for the entire sample. The 2 x 2 design consisted of two levels of achievement motivation and two levels of status of information (known and unknown). The 2 x 3 design had the same two levels of status of information and a three level variable, group arrangement for discussion (like-high, like-low and unlike). ANOVA procedures, t distributions and the Tukey Method were employed for the statistical analyses.

The results of the study indicate that no general trait of risk-taking was evident using the two measures of risk-taking. There were significant differences between groups formed on the basis of achievement motivation in verbal risk-taking. Verbal risk-taking by individuals was significantly influenced by the status of the information.

The results of this study provide insight into the psychological trait of risk-taking on the part of students in an educational setting. The identification of risk-taking as a behavior of inquiry by McREL and BSCS in Inquiry Objectives in the Teaching of Biology makes this study a particularly timely area of research.

THE DEVELOPMENT AND VALIDATION OF A QUASI-NONVERBAL TEST FOR MEASURING ATTAINMENT OF RELATIONAL CONCEPTS IN HIGH SCHOOL PHYSICS

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The purpose of this study was to construct and validate an experimental test which would require students in introductory physics to use graphic rather than verbal skills in identifying the relational concepts of physics.

The effectiveness of the experimental test was examined with two types of physics programs, traditional and contemporary-PSSC physics, and tested the following hypotheses:

1. That there are, among selected high school physics classes, a sizeable number of students who achieve relatively higher scores on a quasi-nonverbal test of physics principles than would be expected from their standing on verbal knowledge tests in physics.

2. That scores on an experimental quasi-nonverbal test measuring concept attainment in secondary physics correlate more closely with scores obtained on standardized tests measuring verbal knowledge in contemporary-PSSC physics than they do with scores obtained on standardized tests measuring verbal knowledge in traditional-physics.

A combination of statistical analyses and the judgment of eight experts in the field of physics teaching was used to establish the validity of the experimental test. Two hundred twenty-six students from four schools in central and southern Pennsylvania participated in the study. Students were compared for verbal and nonverbal ability on the basis of their scores on the Lorge-Thorndike Intelligence Test. Verbal knowledge of physics was tested for students in the traditional physics group, with the Dunning Physics Test: Form AM and with the Tests of the PSSC Physics: Series N for those in the contemporary-PSSC physics group.

The experimental test consisted of 73 four-option, multiple-choice items. The students were shown a pair of 2-in. by 2-in. (35-mm.) slides for each item. The stimulus slide was captioned to identify the intended concept. The response slide, showing four possible "answers," was not captioned.

Test data were analyzed by analysis of variance involving a 2 x 3 x 3 factorial design. A partial regression equation was used to predict the most probable score a student would receive on the experimental test, as estimated from his scores for Verbal Ability and Verbal knowledge of Physics.

Test scores for the slide-test and for verbal knowledge of physics correlated more closely for the traditional-physics students than for the contemporary-PSSC physics group. An unexpectedly low percentage (12%) of the conventional-physics students scored lower on the experimental test than predicted by a regression equation, while an unexpectedly higher percentage of the PSSC students, who scored higher on the slide-test than predicted, scored below the national norms on the LT-V test.

The partial correlation between verbal-knowledge scores and the slide-test scores, with LT-V scores held constant, was highly significant for the traditional-physics group. Also, the partial correlation between the experimental test and verbal ability, with verbal knowledge of physics held constant, was negative in value for the traditional-physics group.

The findings of the study indicate that: (a) students of low verbal intelligence can demonstrate their true ability when tested pictorially; and (b) pictorial testing can be a source of data leading to an understanding of how students of different ages, cultural backgrounds and abilities learn concepts in science.

CONCURRENT SESSIONS III

Session IIIa - Symposium----------What Shall We Teach in Environmental Science?

Chairman: Nathan Washton, Queens College, Flushing, New York

Participants: Helmut K. Buechner, Smithsonian Institute, Washington, D.C.

Edward J. Kormondy, CUEBS, Washington, D.C.

Session IIIb - Symposium----------New Thrusts for Science Education

Chairman: Robert R. Buell, The University of Toledo, Toledo, Ohio

Presentations:

"New Thrusts for Science Education: What the Community College Can Do," Thomas Ten Hoeve, Jr., Butler County Community College, Butler, Pennsylvania.

"Biophysics as a Pre-Paramedical Preparation," Beverly W. Miller, Mary Manse College, Toledo, Ohio.

"Simulating Higher Cognitive Abilities in the Laboratory," Norman W. Hunter, Western Kentucky University, Bowling Green, Kentucky.

"Simulated Investigations Designed to Provide Practice in Utilizing Intellectual Skills Necessary for Science Process," Gilbert L. Twiest, Clarion State College, Clarion, Pennsylvania.

"Scientific Deduction and the 'Rule of Law,'" Robert R. Buell, The University of Toledo, Toledo, Ohio.

Discussants:

J. L. Gallentine, North West Missouri State College, Maryville, Missouri.

T. D. Klopfenstein, Kellogg Community College, Battle Creek, Michigan.

Session IIIc - Symposium----------The Nature of Research in Science Teaching

Chairman: David P. Butts, The University of Texas at Austin, Austin, Texas

Participants:

Julian Brandou, Michigan State University, East Lansing, Michigan.

Robert Bridgeman, Stanford University, Palo Alto, California.

Matthew Bruce, Temple University, Philadelphia, Pennsylvania.

Willard Jacobson, Teachers College, Columbia University, New York, New York.

Session IIId - Science Teacher Education--In-Service

Chairman: H. Seymour Fowler, The Pennsylvania State University, University Park, Pennsylvania.

1. "Effects of an ESCP In-Service Institute on Attitudes and Behaviors of Teachers," John R. Hassard, and Sidney P. Smith, Georgia State University, Atlanta, Georgia.
2. "The Adoption and Diffusion of Selected Elementary Science Curriculum Innovation Among Elementary School Teachers," Kenneth R. Mechling, Clarion State College, Clarion, Pennsylvania.
3. "Testing the Effectiveness of Science Teacher In-Service Provided by Industry," Gary L. Awkerman, and William Landrum, Charleston County School District, Charleston, South Carolina.
4. "Investigating the Impact of In-Service Institutes for Teachers on Their Students," Robert L. Uffelman, A. Jon Magoon, Peter Idstein, and Seymour Yolles, University of Delaware, Newark, Delaware.
5. "An Analysis of the Utilization of Pre-Scheduled Science Consultant Service by Elementary School Teachers Engaged in Science Curriculum Innovation," James M. Mahan, Indiana University, Bloomington, Indiana.
6. "Relationships of Selected Characteristics and Behaviors of Teachers Using the Intermediate Science Curriculum Study," Ronald N. Giese, Lock Haven State College, Lock Haven, Pennsylvania.

EFFECTS OF AN ESCP IN-SERVICE INSTITUTE ON ATTITUDES AND BEHAVIORS OF TEACHERS

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and
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During the past decade much research has been done in the area of cognitive growth and development but little has been undertaken in the affective area with reference to teacher training programs. Also, during the same time period, much emphasis and financial support has been forthcoming for various teacher improvement activities, e.g., academic year institutes, in-service institutes, summer institutes and CCSS institutes, but little research has been conducted to evaluate the effects of these activities with reference to attitude and behavioral changes produced in participants.

The purpose of this research was to study teachers' attitudinal and behavioral changes due to participation in an ESCP In-Service Institute (summer and academic year phases).

Twenty-five science teachers representing ten county school systems in Georgia were randomly selected to be involved in the ESCP In-Service Institute.

For the attitudinal portion of the study, data were gathered by utilizing a modified form of the Semantic Differential developed by Osgood, Suci, and Tannenbaum. The attitude-measuring instrument was composed of six concepts (science, science in my life, learning about science, student participation, laboratory and universe) each having four bipolar adjective scales.

Data for the behavioral portion of the study were secured through the utilization of the Science Classroom Behavior Inventory which was modified from an instrument developed by John Smith at the University of Washington. Part A of the inventory is concerned with teacher behavior (26 items) and Part B is concerned with student behaviors (21 items). Both parts of the inventory utilize a bipolar adjective five continuum scale. Items within each of the above two parts were further factored into: (1) developing text material, (2) pre-laboratory, (3 laboratory, and (4) post-laboratory.

The design of the study was a one group, pretest - posttest(1) - posttest(2) with time intervals of two weeks (ESCP summer institute)between pretest and posttest(1) and eight weeks (classroom teaching and bi-weekly workshops) between posttest(1) and posttest(2).

The statistical treatment used for the data was a one-way analysis of variance accompanied by correlated t-test. Also, intercorrelational computations were computed for each test instrument.

THE ADOPTION AND DIFFUSION OF SELECTED ELEMENTARY SCIENCE CURRICULUM INNOVATIONS AMONG ELEMENTARY SCHOOL TEACHERS

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Clarion, Pennsylvania

There has been a serious lack of research concerning the diffusion of educational innovations to the level of the classroom teacher. It was the purpose of this study to determine the feasibility of selecting key teachers to adopt and spread innovations in science teaching methods and materials within their schools. Specifically, it sought to determine (1) whether elementary teachers, identified by their colleagues as opinion leaders for science teaching, adopted and diffused more science teaching innovations than nonleaders; and (2) whether a correlation existed between adoption of science teaching innovations and scores achieved by teachers on either the Rokeach Dogmatism Scale (RDS) or the Minnesota Teacher Attitude Inventory (MTAI).

On the basis of the classification variable, science opinion leadership, two groups of elementary teachers from forty-one schools in western Pennsylvania were randomly selected for study. One group consisted of twenty science opinion leaders and 134 teachers from their respective schools. The other group included twenty-one nonleaders and 119 teachers from their respective schools. The design employed was the before and after control-group design (pretest - posttest).

All teachers received a pretest questionnaire to establish their levels of adoption of ten innovative science teaching investigations characteristic of those produced by three major science curriculum development projects. Typical investigations selected from each project were Mr. O-Relativity (Science Curriculum Improvement Study), Batteries and Bulbs (Elementary Science Study), and Inferring the Characteristics of Packaged Articles (Science--A Process Approach). During March of 1969 the twenty science opinion leaders and twenty-one nonleaders participated in a three-day inservice program. After the RDS and the MTAI had been administered, the participants were instructed in the techniques for using the ten innovative investigations in their own classrooms. In May of 1969 a posttest questionnaire was administered to all teachers in both groups to determine change in level of adoption.

Statistical treatments included: t-tests for uncorrelated data; single classification, completely randomized analysis of variance (ANOVA); and 2 x 2 contingency tables.

Findings indicated that (1) science opinion leaders adopted and diffused no more of the science teaching innovations than nonleaders; (2) a significant, inverse correlation existed between scores on the measure of level of adoption; and (3) no significant correlation existed between scores on the MTAI and change scores on the measure of level of adoption.

Since the adoption and diffusion processes were not facilitated by the identification of science opinion leaders and the concentration of science inservice efforts upon them, one may question the validity of the diffusion model which suggests that the concentration of implementation efforts on opinion leaders is an efficient mechanism for disseminating innovations. Although the model may be applicable for spreading innovations in agriculture, medicine, and commerce, it does not appear adequate for facilitating the adoption of educational innovations that require substantial change in classroom teaching behavior. The significant relationship between the RDS and the adoption of science teaching innovations suggests a need to examine the possibility of identifying low dogmatic teachers and utilizing them as points of innovational input.

TESTING THE EFFECTIVENESS OF SCIENCE TEACHER INSERVICE THROUGH INDUSTRY

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and
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Charleston, South Carolina

The purpose of this study was to determine if secondary science teachers experienced an attitude change toward industry-school relations as a result of participating in a specially structured inservice program -- a program organized by teachers and science supervisor toward the specific goal of relevance to the instructional setting. Industry cooperated in the project by using a pre-established instructional model prepared by the science educators.

The inservice program consisted of twelve sequential Wednesday evening meetings. Each meeting was conducted by a different industry. Speakers were provided advanced information and instruction on preparing their presentation. The presentations were adapted to a model which included behavioral objectives, industry-defined vocabulary, rationale section, and resource listing.

The general substantive hypothesis was that the experimental group would produce a significant (a = .05) positive attitude score change on industry-school functionings when compared to the control group.

The participants were randomly selected from approximately one hundred science teachers who indicated on a questionnaire that they wanted to take part in the experimental program. The teachers represented eighteen schools in the South Carolina coastal region. The experimental group (N=21) included those teachers who attended the twelve meetings. The control group (N=20) did not participate in the program and were randomly selected for only testing purpose. Both groups were told that the test battery results would be used to assist in developing the new industry-school inservice program for teachers. A third group was composed of industrial leaders who participated in the project.

After the inservice program was completed, an attitude test on the relationship between science teaching and industry, developed by the senior author, was administered to the three groups. In addition, the two teacher groups were administered a four-concept Semantic Differential. The four concepts - (1) Technology, (2) Me teaching science, (3) Charleston industry, and (4) Industry aiding my teaching, - were rated on 7-point scales using twelve bi-polar adjective pairs that have been successfully used several times in previous published research.

The attitude test given to the three groups was factor anlyzed by the principal components method. Cattell's scree test confirmed that there was only one factor. The scores were analyzed with a one-way analysis of variance. The control group scored significantly lower (.01 level) than the other two groups. There was no significant difference between the experimental group and the industy-leaders group.

The Semantic Differential was factor analyzed by the principal components method. The usual three factors (evaluation, activity, and potency) were not found. Instead both a scree test and trial rotation to an orthogonal solution by Kaiser's Varimax procedure indicated a one factor solution.

The ANOVA results indicated that the industrialists and the inservice participants seemed to have a more compatible view of the industrial cooperative efforts while the attitude of the control group differed significantly in a negative direction. The study supports the idea that if in fact a communication gap exists between the workings of science teachers and industry, the problem may be resolved through cooperative efforts.

INVESTIGATING THE IMPACT OF INSERVICE INSTITUTES FOR TEACHERS ON THEIR STUDENTS

Robert L. Uffelman, A. Jon Magoon, Peter Idstein,
and
Seymour Yolles
University of Delaware
Newark, Delaware

The study was conducted to determine if the extent and quality of change in high school chemistry students of teachers who participated in institutes as compared with students whose teachers had not participated would serve as a valid measure of the impact of these institutes.

Teachers and students (N = 500+) were stratified according to (1) attendance in an inservice program and (2) geographic location.

The 1967 American Chemical Society (ACS) test was administered as a pre- and posttest. The gain scores were compared by using covariance analyses.

Results revealed that students of the non-participant teachers scored significantly higher than participant teachers on both measures. When means of each of the ten groups were compared it was evident that the two "rural" groups gained relatively little. Such divergence from the general suburban and urban trends might be expected to exist naturally.

Results of this study cast doubt on the practicality of Experimental Design treatment for teacher education research. Institute participation clearly did not lead to higher achievement gains. Another variable might be found in the teachers who volunteer for institutes. Several other issues are left in doubt as a result of using this design.

Alternative designs could prove more useful for measuring the impact of teacher education programs. Our first recommendation for overcoming apparent selection bias would involve using a true experimental design by oversubscribing for the institute programs and randomly selecting from the pool of volunteers. However, this strategy is in conflict with the objectives of most inservice programs. Where practical, the time-series design is recommended. This design involves multiple observations before a planned intervention of an experimental variable, i.e., teacher education. Such studies would start by initiating periodic measure of student characteristics, e.g., achievement or attitude tests, socio-economic data, and goal orientation. Trend analyses would be applied for identifying breaks in chronological patterns within the time series. Then experimental treatments could be initiated to gain further evidence that the variable may have influenced any changes noted.

AN ANALYSIS OF THE UTILIZATION OF PRE-SCHEDULED SCIENCE CONSULTANT SERVICE BY ELEMENTARY SCHOOL TEACHERS ENGAGED IN SCIENCE CURRICULUM INNOVATION

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This study was designed to determine the amount of time during which elementary school teachers actually utilize external science consultants in 20 empirically derived and sharply defined activities construed as supportive to science curriculum installation. The study also examined relationships between patterns of consultant utilization by school faculties and the amount of the new curriculum actually offered to pupils by those faculties. It was the purpose of the study to stimulate increased attention upon the nature and effectiveness of the acts that operationalize the science consultant role.

The Eastern Regional Institute for Education (ERIE) is engineering the installation of Science - A Process Approach in 53 schools of diverse characteristics. With National Science Foundation support, 50 college and university professors systematically have been prepared to render regularly scheduled consultant assistance to collaborating schools.

These consultants make a minimum of 12 full-day visits per school year. It is the basic responsibility of the consultant to interact with innovating teachers, science supervisors, and principals in ways that assist school personnel to teach the new curriculum within established parameters for instructional quantity and quality. During 1969-70 over 690 consultant days were provided, involving 600 teachers (K-5) and 18,000 students.

All consultants submit required data concerning the nature and effectiveness of the consultant role. From a three-year collection of consultant reports, 20 distinguishable consultant activities were identified and defined. During April, May, and June, 1970, consultants, after a standardized briefing session, indicated on especially prepared forms exactly how many minutes they spent with each teacher and administrator on each school visit and the type of consulting activity that consumed those minutes. Each consultant documented how approximately 21 hours of consulting time was utilized by teachers.

Patterns of consultant utilization vary greatly by school. Direct interaction between consultant and teacher inside the classroom while innovative science instruction is underway tends to be avoided. Less consultant time is requested for demonstration teaching, observation of science instruction, follow-up conferences, instructional progress assessment, curriculum articulation from grade-to-grade, and grade level in-service sessions than most science educators and curriculum change agencies probably estimate and desire. More consultant time is utilized for social conversations, equipment procural and management, and "waiting around to be asked to help" than was assumed by ERIE (and probably by science consultants in general).

Rather modest consultant preparation times for school visits emerge. A disconcerting number of teachers not teaching the innovative science program on consultant visitation day is revealed. Different patterns of consultant utilization are associated with large schools (12 to 24 teachers) as compared to small schools (5 to 11 teachers). Certain patterns of consultant utilization are associated with more extensive implementation of the curriculum.

The external consultant increasingly is becoming a key component of curriculum installation strategies. A shortage of empirical data on the school based performance of consultants exists. The role of the external consultant must be systematically analyzed and consultant activities that optimize high quality curriculum installations identified and promoted. ERIE offers this study as a part of its extensive, longitudinal research on the external consultant as a supportive force for science curriculum change.

RELATIONSHIPS OF SELECTED CHARACTERISTICS AND BEHAVIORS OF TEACHERS USING THE INTERMEDIATE SCIENCE CURRICULUM STUDY

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Lock Haven, Pennsylvania

Are the teacher characteristics selected related to the extent that participants in the study exhibit various categories of behavior defined as desirable or undesirable in the ISCS model of science teaching?

The teacher characteristics assessed were: knowledge of the processes of science; attitudes toward science; ten personality traits identified by the Guilford-Zimmerman Temperament Survey; attitude toward teacher-pupil relationship; knowledge of the ISCS course content; teacher's sex; years teaching experience; and grade level assigned.

Three twenty-minute samples, of each of the twenty-eight teachers' classroom behaviors were encoded using the Science Teacher Behavior Inventory, a scheme developed to encode behaviors stressed as desirable or undesirable in the ISCS model for science teaching. The Mann-Whitney U Test and the Pearson r were used to determine the statistical relationships of the selected teacher characteristics to teacher behavior. The findings and conclusions were:

1. Personality traits generally were not predictors that participants would exhibit behaviors espoused in the ISCS model. Two exceptions were objectivity and masculinity.

2. Knowledge of the processes of science and of ISCS content were predictors of the participants ISCS teaching behavior.

3. Attitudes toward science and towards teacher-pupil relations were fair predictors of participants exhibiting behaviors espoused in the ISCS model.

4. That the cognitive characteristics were more strongly related to teacher behaviors than were attitudinal characteristics indicated that some participants exhibited behaviors congruent with their knowledge of the processes of science and the ISCS Curriculum. However, at the more subtle attitudinal level these participants had not completely adopted the ISCS model.

5. The relationships of grade level taught to teacher behaviors indicated that participants teaching students who have had a more traditional course in science had more difficulty exhibiting the ISCS model behaviors, probably because their students expected them to assume a more traditional classroom role.

Session IIIe - Junior High Science Including Evaluation of Special Curricula

Chairman: Cornelius J. Troost, University of California at Los Angeles, Los Angeles, California.

1. "An Analysis of Changes in Associative Responses to Selected Science Concept Words by Seventh-Grade Pupils During Study in a Modern Science Curriculum," Victor D. Morris, Indiana University Northwest, Gary, Indiana.
2. "Structures in Science Teaching and Learning Outcomes," Arnold L. Trindade, Teachers College, Columbia University, New York, New York.
3. "A Comparison of the Performance of ISCS and Non-ISCS Ninth-Grade Science Students on Several Piaget-Type Tasks," Thomas G. Teates, Virginia Polytechnic Institute and State University, Blacksburg, Virginia, and Paul Westmeyer, The Florida State University, Tallahassee, Florida.
4. "Comparisons Between Reading Abilities and Achievements in Two Aspects of Science in Seventh-Grade Students of Various Socio-Economic Levels," David R. Stronck, The University of Texas at Austin, Austin, Texas.
5. "An Analysis of Student Outcomes Using Audio Tapes as a Supplement to Reading in the Level One Course of the Intermediate Science Curriculum Study," Richard W. Gates, St. Bonaventure University, St. Bonaventure, New York.
6. "A Semantic Differential Evaluation of Attitudinal Outcomes of Introductory Physical Science," Alfred R. Hecht, Moraine Valley Community College, Palos Hills, Illinois.

AN ANALYSIS OF CHANGES IN ASSOCIATIVE RESPONSES TO SELECTED SCIENCE CONCEPT WORDS BY SEVENTH-GRADE PUPILS DURING STUDY IN A MODERN SCIENCE CURRICULUM

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One basic component of science curriculum development involves how best to communicate to pupils the meanings of the words used to label the concepts included in a particular content area. In a science curriculum much of the logical structure is imposed by the selection of the content, since the verbal meaning of each concept word is defined in terms of its interrelations with the other concept words with comprise the content.

This study was designed to utilize word association techniques in the investigation of changes in the verbal behavior of individuals during their study of a self-paced, individualized, science curriculum organization. The specific verbal behaviors studied were the changes in associative responses to selected science concept words which were used as stimulus words on a word association pretest and posttest. The changes in verbal behavior observed were then related to the frequency of occurrence of the concept words in the instructional material. It was anticipated that this technique might be of particular interest and value during the formative evaluation stages of curriculum development.

The word association test consisted of the concept words WORK, FORCE, TIME, DISTANCE, FRICTION, VARIABLE, MEASURE, and WEIGHT. Subjects received a random order of the eight concept words on both the pretest and posttest. The subjects were allowed one minute per stimulus word to write free-association responses. An achievement posttest was also administered following the word association posttest.

Evidence was found that the frequency of occurrence of the concept words in the instructional material is a significant factor in relation to the amount of learning which occurs. Subjects who were high achievers on the achievement test gave significantly more stimulus words as responses than did low achievers. Concept words which occurred more frequently in the material were also given more frequently as responses on the word association posttest by both high and low achievers than were the low frequency concept words.

The results of the present research suggest that the use of the word association technique may provide the kind of specific information needed to structure the verbal organization of the instructional material in order to meet a variety of learner needs. This approach could be used to determine which concepts and conceptual interrelationships are not being learned, and thus point to specific areas of needed revision.

STRUCTURES IN SCIENCE TEACHING AND LEARNING OUTCOMES

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The objective of this study was to examine the influence of serial order in teacher communicated content on the acquisition of verbal knowledge. A concept of kinetic structure in teaching was used which is a specification and serial ordering of subject matter in teacher statements. The amount of structure in a communication is the number of words held in common in pairs of teacher statements.

There were three types of communications: (1) Low structured (Random), (2) Intermediate structured (Static), and (3) High structured (High Kinetic). The low structured communication had verbal statements with a minimum number of common elements or scientific terms between them, i.e. stimuli in successive pairs of statements do not repeat and have no common properties. The intermediate structured communication was produced by including common elements or scientific terms to show some degree of relatedness. The high structured communication was realized by including a large number of terms held in common by contiguous verbal statements or units within a communication.

The theory underlying this experiment was that high structured communications would yield greater reinforcement of acquired responses since they contain verbal elements in common. They produce proactive facilitation and strengthen the serial association of acquired responses.

Three experimental groups consisting of eighth graders controlled for I.Q. and for science achievement on the Stanford Achievement Test were administered the above three variously structured treatments: random, static, and high kinetic. The treatments were also varied along three content areas in biology: (1) digestive system, (2) life cycle of bread mold, and (3) scientific names.

An analysis of covariance test performed on the data indicated the following results. Subjects receiving low structured (random), intermediate structured (static) and high structured (high kinetic) science communications show significant differences in acquisition of information both with respect to descriptive and factual knowledge - response strength, and with respect to knowledge of the order in which component parts of a physical system, or the temporal events of a life cycle can be organized - response order. This condition was true for acquisition data but only partially true for retention data.

This study has particular relevance to teacher communicated content. It leads to a better understanding of various ways of organization in classroom communications. The quantitative evaluation of teacher discourse as defined by Kinetograms and the presentation of a definite number of scientific terms in three different communications with known degrees of structure as evidenced through mathematical coefficients, B_1 and B_2, provided a controlled context for evaluating teaching. Variations in structure of teacher discourse could then be related to variation in learning outcomes: response strength and response order. The patterns of teacher structured discourse exhibiting random, static and high kinetic structures as assessed by Kinetograms revealed corresponding significant differences in the acquisition of information by pupils.

A COMPARISON OF THE PERFORMANCE OF ISCS AND NON-ISCS NINTH-GRADE SCIENCE STUDENTS ON SEVERAL PIAGET-TYPE TASKS

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The purpose of this research was to determine whether ninth-grade students completing the third year of the Intermediate Science Curriculum Study (ISCS) instructional sequence performed differently on selected Piaget-type conservation tasks than ninth-grade science students who had not worked with the ISCS materials. Nineteen conservation tasks were administered to 249 ISCS and 239 non-ISCS students in classroom size groups via 35 mm color slides and a tape-recorded protocol. Three to six tasks were included in each of the following conservation categories: amount, weight, volume, length, and area.

Students in both treatment groups were classified as high, medium, or low ability on the basis of their performance on standard mental ability or educational development tests. It was hypothesized that there would be no difference in ISCS and non-ISCS student performance on the conservation tasks and that there would be no difference in the performance of high, medium, and low ability students on the tasks. A student was considered to be a conserver if he selected the correct response for all of the tasks in the test relative to a given type of conservation.

The data were analyzed using analysis of variance. The experimental unit was all of the students tested at a school. Each ability level within each school was treated as a repeated measure on the individual unit. There was no difference at the .05 level of significance in the performance of ISCS and non-ISCS students on the tasks test and there was no significant interaction between treatment and ability level. However, there was a difference at the .05 level of significance in the performance of students of different ability levels. In both treatment groups, higher ability students performed better than lower ability students. The order of decreasing average percentage of students correctly responding to all of the items in the sets for the various types of conservation was: amount (96), weight (87), length (48), volume (23), and area (4).

The method of presentation of the tasks proved efficient and apparently was effective. Further research is needed to establish the validity of using only the response selection data in a group presentation of tasks to measure the attainment of conservation characteristics.

COMPARISONS BETWEEN READING ABILITIES AND ACHIEVEMENTS IN TWO ASPECTS OF SCIENCE IN SEVENTH-GRADE STUDENTS OF VARIOUS SOCIO-ECONOMIC LEVELS

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The purposes of this study were to answer the following questions:

1. Does the Portland Science Test have a minimum reliance on reading skills and measure two distinct aspects of science?

2. Do socio-economic levels indicate the differences in reading abilities and in science achievement for seventh-grade students?

A total of 475 students took the Advanced Level Survey Test in the Burnett Reading Series, Form A. The same students took the Portland Science Test which is divided into two parts: half of the sixty questions are on the processes of science; the other half consider the products of science. Processes were defined as the ways in which scientists learn; products, as what scientists have learned. To avoid reliance on reading skills, the Portland Science Test consists of pictures and a series of questions about the pictures. The reliability and validity of this unpublished test were established in Portland, Oregon. Its use had been restricted to students in that city.

Seven parochial schools of San Francisco provided samples of children from a broad range of socio-economic levels defined by a recent sociological study. These schools had great similarities in the quality of teachers, content of courses, and method of instruction. The mean of the scores of all these seventh-grade students in each class was compared with the means of all the other classes. Comparing the seven averages on the reading test produced 21 critical ratios with six of these significant at the one percent level and two significant at the five percent level. The pattern in ranking of the schools followed especially the education level of the adults in each parish.

Comparing the seven averages on the Portland Science Test produced 21 critical ratios for the total score, 21 for the process questions, and 21 for the product questions. In each of these three categories the Portland Science Test uncovered more significant differences than did the reading test. The ranking of the schools on the total score, on the process score, and on the product score differed somewhat from the ranking of the schools by reading abilities. Nevertheless, there remained a substantial trend for the students with superior reading ability to score higher on the science tests. The coefficients of correlation for the reading test with the total scores on the Portland Science Test averaged 0.639;

for the reading test with process questions, 0.584; for the reading test with product questions, 0.572. The coefficients of correlation between the process questions and the product questions of the Portland Science Test averaged 0.635.

The entire study demonstrated a strong correlation between socio-economic levels and achievements in reading and in science. The study also gives some weak support to the goals of the authors of the Portland Science Test: (1) The test has minimum reliance on reading skills and (2) The test measures two distinct aspects of science (processes and products).

AN ANALYSIS OF STUDENT OUTCOMES USING AUDIO TAPES AS A SUPPLEMENT TO READING IN THE LEVEL ONE COURSE OF THE INTERMEDIATE SCIENCE CURRICULUM STUDY

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The purpose of this study was to analyze the effectiveness of audio-tapes used in cassette type play-back machines when used by poor readers as a supplement to reading the Intermediate Science Curriculum Study first level materials.

The study was conducted over one academic year (1969-70). One hundred poor readers, selected at random from one representative junior high school were assigned to experimental and control groups. Two groups of twenty-five students used audio-tapes, while two other groups of twenty-five did not. The same teacher taught both classes of poor readers, and both groups followed an identical ISCS program.

The tape material consisted of the textbook being read by a narrator, enabling students to hear directions, suggestions and ideas as they followed the written words. Each student had his own play-back machine since he worked at his own rate and would be at varying parts in the course at a given time.

Comparison of end of year measures were made in the areas of: (1) subject preference; (2) understanding of science; (3) science vocabulary; (4) total vocabulary; (5) reading comprehension; (6) reading grade level; (7) understanding of ISCS principles; (8) teacher evaluation; and (9) rate of progress using the ISCS materials.

Analysis of covariance utilized adjusted means on pretests and posttests with each instrument (with the exception of the Teacher Performance Scale). The results of such analyses indicate that the following conclusions can be made:

1. Students using audio tapes as a supplement to reading in the first level ISCS course have a significantly greater preference for science than those students not using audio tapes as measured by the Prouse Subject Preference Test. When further compared by a t test, students using tapes displayed a specific increase in preference toward science while the non-tape students displayed a significant decrease in preference.

2. Students using audio tapes as a supplement to reading in the first level course have achieved course principles and concepts to a significantly greater level than those students not using audio tapes as measured by the printed ISCS Final Examination. Correlations between reading level and the ISCS

Final Examination were made in order to gain information concerning the relationship between reading gain and ISCS achievement. The results suggested the gains on the ISCS Final Examination in the tape group were caused by the learning experiences which included the use of audio tapes. In the non-tape group low scores were apparently caused by a guess factor score.

3. Students using audio tapes as a supplement to reading in the first level ISCS course have the same understanding of the scientific enterprise, the scientist, the methods and aims of science as those students not using audio tapes as measured by the TOUS.

4. Students using audio tapes as a supplement to reading in the first level ISCS course have a significantly greater science vocabulary reading grade level than those students not using audio tapes as measured by the California Reading Test.

5. Students using audio tapes as a supplement to reading in the first level course have a significantly greater overall reading vocabulary level than those students not using audio tapes as measured by the vocabulary section of the California Reading Test.

6. Students using audio tapes as a supplement to reading in the first level ISCS course have no significantly different overall reading grade level compared to students not using audio tapes as measured by the California Reading Test. There were, however, gains in reading level for both groups. The students using audio tapes had a reading level of 5.67 prior to the experiment and a 7.47 reading level at the end of the experiment. The students not using audio tapes increased their reading level from 6.10 to 7.48.

7. There is no significant difference between the rating of teacher performance as given by students experiencing audio tapes and those not using such tapes as indicated by end of year measures only.

8. Both groups of students proceeded at different rates during the course, depending upon the material being studied. At the end of the course both groups were proceeding at about the same rate.

A SEMANTIC DIFFERENTIAL EVALUATION OF ATTITUDINAL OUTCOMES OF INTRODUCTORY PHYSICAL SCIENCE

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To test school year and calendar year attitudinal changes, random samples of 240 Introductory Physical Science (IPS) and 240 non-science students were assigned to separate Solomon four-group designs with non-equivalent control groups.

Student attitudes were measured by a semantic differential instrument with six concepts (SCIENTISTS, SCIENCE, RESEARCH DONE BY SCIENTISTS, HIGH SCHOOL SCIENCE TEACHERS, HIGH SCHOOL SCIENCE COURSES, and EXPERIMENTS DONE IN HIGH SCHOOL) evaluated in terms of 16 bi-polar, seven-interval, adjective scales.

Principal components analyses across all subjects and observations were performed for each concept. Resultant factors were rotated to simple structure according to the varimax criteria. For each concept, one or two evaluative factors (e.g., Enjoyment and Importance) and one or two non-evaluative factors (e.g., Potency and Activity) emerged. These factors accounted for about half the common variance among 16 scales.

Principal components analysis reduced student responses on 96 adjective scales to scores on 18 factors. Factor scores comprised the data used to test the research hypotheses by multivariate analysis of variance.

Compared with changes in non-science students' attitudes over a school or a calendar year, significant increases were not demonstrated in IPS student attitudes toward the six concepts studied. Over a school year, IPS mean factor scores became less favorable for 15 of 18 factors. Over a calendar year, IPS mean factor scores became less favorable for 10 of 18 factors.

Results of this study suggest a number of recommendations for procedures to be followed and problems to be investigated in further research.

1. To determine and improve reliability and validity, a semantic differential should be pretested on a population similar to the one to be investigated.

2. Factor scores should be computed on the basis of study data rather than on the basis of previous research.

3. Although initial analysis should include all concepts to determine whether a common factor structure applies to all concepts, concept-scale interaction probably will dictate separate concept analyses.

4. Principal components factor scores, which weight, according to factor loadings, each scale comprising the summary score should replace the usual scoring method of assigning equal weight to each scale with major loadings on a factor.

5. If the experimental design permits, multivariate analysis of variance of principal components factor scores is feasible and effective.

6. Low instrument reliability and favorable initial student attitudes indicate the need for development of more reliable attitude measures with greater sensitivity in the favorable range of evaluative factors.

7. Consistent with findings of other studies using objective attitude measures, the lack of significantly more favorable attitudes as an outcome of IPS instruction indicates the need for developing and evaluating science courses designed to produce affective as well as cognitive changes.

8. Although the 12 months covered by this study exceeded the length of most attitude studies, inadequate understanding of attitude stability suggests the need for studies considering changes over even longer periods of time.

9. Consistent with the number of significant treatment-by-sex interactions obtained in this study, interaction hypotheses should be tested in further studies.

GENERAL SESSION

Chairman: George Mallinson, Western Michigan University, Kalamazoo, Michigan

Speaker: Gene V. Glass, Laboratory of Educational Research, University of Colorado, Boulder, Colorado

"The Implications of Recent Developments in Educational Research to Science Educators"

CONCURRENT SESSIONS IV

Session IVa - Behavior and Attitude Studies and Models

Chairman: Wayne Ransom, Temple University, Philadelphia, Pennsylvania

1. "An Investigation of Structured Observation Experiences as a Self-Improvement Technique for Modifying Teachers' Verbal Behaviors," Joseph H. Jacobs, Union Free School District #4, East Northport, New York.
2. "Changes in Teaching Behavior of Preservice Elementary Education Majors as a Result of Training in Using the IAST Base, A System of Interaction Analysis," Gene E. Hall, University of Texas at Austin, Austin, Texas.
3. "Will Students Fake a Science Support Scale When Given Direct and Indirect Instruction To Do So?" Marvin F. Wideen, University of Colorado, Boulder, Colorado.
4. "A Statistical Study of Attitudes Toward Self, Peers, Teachers and School of Underachieving Junior High School Students in Jacksonville,Florida, Using a Specially Formulated Q-Sort Test," Jack Megenity, University of Florida, University of Florida, Gainesville, Florida.
5. "An Investigation Into the Role of Teaching Models in Science Concept Learning in Secondary School Biology," Kenneth H. Baker, Central Washington State College, Ellensburg, Washington, and H. Seymour Fowler, The Pennsylvania State University, University Park, Pennsylvania.
6. "Elementary School Science Instruction: Words, Ideas, and Instructional Materials," Joseph I. Lipson, Plantation, Florida.

AN INVESTIGATION OF STRUCTURED OBSERVATION EXPERIENCES AS A SELF-IMPROVEMENT TECHNIQUE FOR MODIFYING TEACHERS' VERBAL BEHAVIORS

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The study was designed to determine whether changes in verbal interaction patterns would be demonstrated in the classrooms of teachers who had received observation training and subsequently performed classroom observations, using a structured checklist of classroom interaction.

Twenty-six teachers, from different grade levels of five school districts outside of New York City, were divided evenly into experimental (E) and Control (C) groups. Teachers in the E group received three days training in the use of an observation sign system checklist, and subsequently made an average of thirty-six observations, interspersed in their regular teaching schedule, over a period of six days. Teachers in the C group conducted their classes without participating in the training or observation experiences.

An average of 260 minutes pre- and post-treatment verbal interaction data were obtained from tape recordings made during the regular class sessions of the teachers in the E and C groups.

Flanders Interaction Analysis System was used to analyze and code the classroom interaction data into ten categories of verbal behavior. An average of 68,000 pieces of data was obtained for each group of teachers.

The coded data were entered onto matrices which were used to obtain the twenty indices of teacher influence and pupil response to measure the changes in the verbal interaction patterns of the teachers in the study.

Pre- and post-treatment means, for each of the twenty indices, were compared and subjected to an analysis of covariance to test the significance of differences between the E and C groups.

Teachers who had received observation training and experiences demonstrated significant changes in their verbal teaching behaviors, in that they:

1. increased their acceptance and use of student ideas.
2. developed the students' ideas more extensively.
3. asked more detailed questions.
4. diminished their use of lecture, directions, and criticism.
5. talked less during the total class interaction.

6. responded more indirectly after pupil contributions.
7. enlarged their total indirect verbal behaviors and decreased total direct verbal behaviors in both the cognitive and affective areas.
8. expanded their total extended indirect influences and reduced their use of extended direct influences.

Although the E group significantly expanded their total indirect behaviors, increases of the following individual aspects of indirect behavior were not significant:

1. Teacher acceptance and clarification of student feelings; the E group's mean had increased to equal that of the C group, which had not changed.
2. Teacher praise of student actions; the E group increased while the C group had decreased slightly.

Pupil participation increased significantly in the classes of the teachers who had engaged in the observation program.

Differences were not significant for extended pupil talk and pupil talk indicating self initiation or use of students' own ideas.

Evidence that teachers can modify their own classroom verbal behavior patterns was obtained. After receiving training and performing observations, with a checklist to analyze classroom processes, teachers employed more indirect and less direct verbal behaviors in their classes. Recommendations are made to include structured observations in teacher education, pre- and in-service. Suggestions are made for replication studies using other dependent and independent variables.

CHANGES IN TEACHING BEHAVIOR OF PRESERVICE ELEMENTARY EDUCATION MAJORS AS A RESULT OF TRAINING IN USING THE IAST BASE, A SYSTEM OF INTERACTION ANALYSIS

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Over the years there has been some controversy regarding the types of changes micro teaching and interaction analysis actually bring about in the teacher. Researchers have demonstrated that teachers trained using micro teaching procedures can exhibit the specified behaviors at criterion level. Teachers trained in using interaction analysis have also been shown to change their behaviors. The most commonly used system of interaction analysis for training teachers and for measuring teacher change has been the ten category Flanders System. However, the Flanders System of interaction analysis was not designed with an emphasis on the teaching of science.

In this study an attempt has been made to train teachers in the use of a fourteen category system of interaction analysis. The categories were designed specifically to emphasize behaviors thought to be desirable in the teaching of science. The teacher's behavior was then measured using an expanded set of categories so that more subtle types of changes in teaching behavior could be identified.

During the 1968-69 academic year an interaction analysis category system, the Instrument for the Analysis of Science Teaching (IAST base), which included behaviors directly related to the teaching of science was developed. An Instructional Module, the Analysis of Teaching Behavior (ATB), a description of one way to train teachers in using the IAST base was also developed.

In the summer of 1969 six college professors of science education from five different colleges in Texas were introduced to the ATB module. During the fall semester the professors used the ATB module with a total of six experimental science methods classes.

The students in the science methods classes made audio tapes of a low ratio teaching situation before and after presentation of the ATB module. A total of 86 students participated in the study. The audio tapes were then classified by a trained observer using the IAST version 2, a 32 category system of interaction analysis, which is an expansion of the IAST base. The pre/post data were then compared using one way analysis of variance.

The following changes in teaching behavior, statistically significant at the .05 level, were identified: (1) An increase in a) the acceptance of students' feelings; b) teacher closed questions; c) student overt activity; and d) group student responses; and (2) A decrease in a) teacher clarification questions; b) teacher lecture; c) teacher looking at lesson plan; d) teacher handling of equipment; e) student open statements; and f) in general, wait time.

The conclusion from this study is that indeed the frequency of certain teacher behaviors thought to be desirable and undesirable in teaching science can be modified by training teachers in using the IAST base as described in the ATB module. However, some of the behaviors have shifted in undesirable directions e.g., wait time. Therefore the ATB module instructor should be advised that he may wish to place emphasis on the frequency of certain behaviors.

WILL STUDENTS FAKE A SCIENCE SUPPORT SCALE WHEN GIVEN DIRECT AND INDIRECT INSTRUCTION TO DO SO?

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In recent years measurement in the affective domain has received considerable attention in science education particularly in the area of attitude assessment. Since 1962, the number of tests of scientific attitude has increased. Those recently developed include instruments prepared by Welch and Pella (7), Vitrogen (6), Dutton and Stephens (1), Moore and Sutman (2), and Schwirian (4,5). According to Moore and Sutman, developers of the above instruments have attended to one or more of the following characteristics: specifying of attitudes to be measured; the use of several items to assess each attitude; provision for respondents to indicate the extent of acceptance of an attitude; and concern with intellectual and emotional scientific attitudes.

Two considerations would seem to follow from the literature related to these attitude measures in science education cited above. First, little attention has been given to assessing the effects of respondents' desire to project a favorable or an unfavorable attitude toward science.* Scales typically do not have items designed to mask the purpose of the test, nor does the topic of faking receive attention by those developing measures. Secondly, there have been few attempts to subject the measures cited above to a variety of empirical analyses for purposes of gaining information on the usefulness of the measures as well as their weaknesses and generally contributing to the data pool surrounding each test.

This study attempts to address the former concern directly and hopefully contribute to the latter.

The purpose of this study was to assess the effect on the Schwirian Science Support Scale of a respondent "faking" either a good attitude toward science or a poor attitude toward science.

Specifically, the study attempted to determine if (a) students who were asked to deliberately fake a good or a poor attitude toward science have significantly higher or lower scores respectively from those who follow normal directions, (b) students who encouraged through subtle directions to do well or poorly will, in fact, attempt to "fake" the attitude scale, and (c) differences in treatment were consistent for sex, type of major, or G.P.A.

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* Considerable attention has been given this question in psychology measurement.

The first hypothesis was designed to determine if subjects can fake an attitude scale such as the Schwirian measure; the second hypothesis was designed to address the question of whether or not students will fake a measure when it appears to their advantage to do so.

The Schwirian Science Support Scale was developed on the basis of Barber's Science and the Social Order. It was designed to measure science support and the author suggests that the test can be used to assess attitude changes in research. Being somewhat typical of the several Likert scales thus far developed, the use of this test permits the investigator to address the general question of student "faking."

If it is found that the scale can be easily faked by respondents and that respondents do in fact attempt to fake it, then perhaps when using the measure one is not measuring attitude but rather the respondents perception of how he wants to appear at a particular time.

In addition, the study provides prospective test users with additional information with which to assess the usefulness of the measure.

First year biology students (N = 240) were randomly divided into five groups and administered the 40-item Schwirian Science Support Scale each receiving different written directions. One group was asked to respond according to normal directions as given in the original scale. A second group was directly asked to fake a positive attitude toward science and a third a negative attitude. A fourth group received subtle directions suggesting a highly positive correlation between attitude measures and grade point average. A fifth group received directions suggesting that on a scale such as this a negative attitude toward science was an asset. Results of comparisons of group means to determine the effects of different levels of treatment and factor analysis to test for interaction of factors are reported.

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A STATISTICAL STUDY OF ATTITUDES TOWARD SELF, PEERS, TEACHERS AND SCHOOL OF UNDERACHIEVING JUNIOR HIGH SCHOOL STUDENTS IN JACKSONVILLE, FLORIDA, USING A SPECIALLY FORMULATED Q-SORT TEST

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The problem to which this study is directed has been the investigation of the attitudes of the students in the DISCUS program toward themselves, their peers, their teachers, and their school by applying a Q-sort instrument especially formulated for this study.

The DISCUS program,a demonstration of an improved science curriculum for underachieving students, involves the junior high school science classes of more than sixty teachers in twenty different junior high schools. Briefly, the mechanics of this program are:

(1) Underachieving students were separated from their more academically successful peers,

(2) Teachers who voluntarily offered to work with this project and the students were assigned on a random basis to treated and non-treated classes,

(3) Special instructions for making use of a success-oriented classroom environment and for using a directed discovery approach were provided for the teachers of the treated classes,

(4) Special materials of instruction were provided to the teachers of treated classes, and

(5) The program, in effect since the spring of 1967, was designed to assist underachieving, educationally disadvantaged youth to acquire a more favorable attitude toward schooling.

This study, making use of the Q-sort method, has been designed to determine if differences in the specified attitudes exist between various selected groups of the students in this program. The Q-sort is a kind of procedure used for evaluating selected attitudes that center around a forced sorting and ranking of related items and statements about these selected attitudes.

The Q-sort test formulated for this study was given to 380 treated and 325 untreated students. Using the computer, the data from this test were analyzed.

The main results of this study show the following for attitudes toward self, peers, teachers, and also school:

(1) Significant difference exists between the means of the treated and the untreated students.

(2) No difference exists between the means of the black and the white students.

These results of this study would seem to indicate that the DISCUS success-oriented teaching program has a definite effect on the attitudes of the students. It remains for other research to provide answers concerning the merit of this effect.

AN INVESTIGATION INTO THE ROLE OF TEACHING MODELS IN SCIENCE CONCEPT LEARNING IN SECONDARY SCHOOL BIOLOGY

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and

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The purpose of this study was to determine the relative effectiveness of two methods of teaching selected facts and concepts from molecular biology to a group of tenth grade biology students. The study was designed as an experimental investigation into the role of two and three dimensional teaching models in science concept learning.

The experimental and control groups were each composed of one class of high ability secondary biology students and one class of low ability secondary biology students. The treatment given to the experimental group consisted of a lecture-demonstration type presentation reinforced by making maximum use of a series of sensory aids based upon and derived from a three dimensional model of DNA. These sensory aids were designed and developed by the investigator to be used as teacher manipulated demonstration devices and student manipulated learning aids. The control group was taught identical content using a strictly lecture approach involving verbal exposition only with no teacher demonstration or student manipulation of models. The research design was, therefore, one of two treatment groups, experimental and control, involving the use of two and three dimensional models with the experimental group on both a demonstration and manipulation basis. Neither two nor three dimensional models were used with the control group.

All experimental data collected during the project were analyzed for significant differences in subject matter achievement between the two treatment groups by the use of an adjusted analysis of variance derived from an analysis of covariance routine. Each of these analyses was conducted via a computer program designed to run an analysis covariance with two independent variables or covariates and one dependent variable or criterion measure.

There were nine experimental hypotheses stated as no significant difference in subject matter achievement between the two treatment groups. The first three hypotheses were major hypotheses dealing with comparisons of one total score and two subscores for all students in the study. The remaining six hypotheses were minor hypotheses. The first three minor hypotheses dealt with total scores and subscores for the high ability group. The last three minor hypotheses pertained to total scores and subscores for the low ability group.

The experimental findings showed that only the first major hypothesis could be rejected on the basis of the computed F-value. The F-values generated for major hypotheses two and three and for each of the six minor hypotheses were not sufficient to warrant rejection at the .05 level.

These results would lead to the conclusion that the experimental treatment involving the use of two and three dimensional models made a significant difference in subject matter achievement among those students in the model group as demonstrated by the statistical significance achieved in major hypothesis one. The failure to achieve significance in eight of the nine experimental hypotheses would tend to indicate that the difference in achievement while significant in the case of the first major hypothesis was not significant at any other level.

ELEMENTARY SCHOOL SCIENCE INSTRUCTION:

WORDS, IDEAS, AND INSTRUCTIONAL MATERIALS

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The purpose of the paper is to report the results of analysis and experience in innovative elementary school science education for the last eight years. The following conclusions are presented:

(1) Innovative elementary school science programs have not had the effect upon the educational experience which their designers projected.

(2) Materials and equipment can be rapidly distributed throughout the educational system. Educational materials and equipment make a definite change in the educational process. However, the change is relatively small in the direction hoped for and relatively large in unanticipated directions.

(3) In order for new materials and equipment to have the effect intended, complex new ideas must be transmitted to a large audience composed of teachers, administrators, parents, and the general community.

(4) There is little likelihood that under the present condition of the educational community or the society at large, that elementary education can generate the public discussion which would be necessary for large scale innovations to have the effect which the effort expended calls for.

(5) There is considerable evidence that the vocabulary level of students correlates with a great many achievement measures. The paper will review the evidence on this matter.

In the absence of either the resources or the public disposition to generate the needed public discussion for large scale structural and curriculum changes to be effective, an immediate program of vocabulary and concept development in the field of elementary school science would probably have a much higher cost benefit ratio that massive programs which require a parallel program of adult general education in order to be effective.

(6) In addition to the immediate program of vocabulary and concept development in science, all those interested in massive changes in the educational system should work on developing various kinds of dependable knowledge about the educational process, about the social system of education, and the way in which educational systems interact with the society at large.

(7) A part of such an attempt would be a network of experimental schools. A particular point in making experimental schools credible and useful is the extent to which documentation, evaluation, and research are conducted by independent, autonomous professionals with a variety of methodological backgrounds.

Session IVb - Elementary School Science--Evaluation, Inquiry and Teaching Techniques

Chairman: Rose Lammel, Wayne State University, Detroit, Michigan

1. "Pupil Achievement in Science a Process Approach," William Torop, Saint Joseph's College, Philadelphia, Pennsylvania.
2. "Post Laboratory Discussion Techniques and Inquiry Skill Development in Science," Eugene Abraham, Temple University, Philadelphia, Pennsylvania, and Miles Nelson, University of Wisconsin, Madison, Wisconsin.
3. "Differential Response to Structure of Advance Organizers in Science Instruction," John J. Koran, Jr., and Mary Lou Koran, The University of Texas at Austin, Austin, Texas.
4. "An Experimental Investigation of the Effect of Performance Class on the Rate of Acquisition of Process Behavioral Objectives," Richard F. Rosen, University of Maryland, College Park, Maryland.
5. "The Inquiry Skills Measures," Miles A. Nelson, University of Wisconsin, Madison, Wisconsin, and Eugene C. Abraham, Temple University, Philadelphia, Pennsylvania.
6. "Classroom Verbal Behavior as Related to Teachers' Perception of Pupils in Fifth-Grade Science Classes," Robert E. Rogers, Queens College, Flushing, New York.

PUPIL ACHIEVEMENT IN SCIENCE A PROCESS APPROACH

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The problem considered in this study was to determine to what extent elementary school children were achieving the objectives of Science - A Process Approach (SAPA).

The subjects were first, second, and third grade pupils in the six elementary schools of Marple Newtown School District, Newtown Square, Pennsylvania, during the school year 1969-1970. Two pupils, selected randomly, in each class for each SAPA exercise taught, were given the competency measure for the particular exercise. A total of 1480 tests were thus administered.

The average percentage of correct responses in the first grade (N=474) was 90%; in the second grade (N=496) 86%; and in the third grade (N=510) 87%. Percentages were also computed for individual exercises in each grade.

SAPA was originally designed so that 90% of the pupils should achieve 90% of the stated objectives. The first--and only--published evaluation indicated an overall achievement of 82%.

There is not enough time, in the average school day, to permit the teacher to give a competency measure to each pupil. The present figures, however, indicate that the objectives of the program are being achieved in Marple Newtown.

Figures for individual exercises indicate which exercises might need improvement--either in the teacher's guide itself or the questions that are asked of the pupil in the competency measure.

POST LABORATORY DISCUSSION TECHNIQUES AND INQUIRY SKILL DEVELOPMENT IN SCIENCE

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and

Miles Nelson
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A study was conducted to determine the effects of two distinct discussion techniques on the development of four inquiry skills emphasized in most of the new elementary school science curricula. The four inquiry skills investigated were the children's ability to 1) make observations, 2) make inferences based on observations, 3) formulate tests in order to verify inferences and, 4) classify. A predominantly white middle-class school, and a predominantly black lower class school provided students for the investigation.

Four sixth grade classes were used in each school with two teachers employing both discussion techniques. One technique, designated as a non-probing discussion, emphasized the collection of data by the students, but left the processing and generalizing to the teacher. This was done in the form of a didactic lecture in which the teacher told the class what they should have observed and explained the reasons for the observations. The children were not given the chance to process the data that they had collected, and the questions were limited to either simple recall or data collection. The children's responses were immediately accepted or rejected by the teacher based on previously determined criteria.

The second discussion technique, designated as a probing discussion, placed the burden of data processing as well as data collecting on the students. Concept formation and generalizations were encouraged by asking the students to formulate inferences based on their observations, and to discuss possible ways of verifying or evaluating these inferences. Student responses were never specifically accepted or rejected by the teacher, but rather were left open for the class to discuss and analyze. Inconsistencies arising out of the student's observations served as a focus for class discussions and were not "explained-away" by the teacher.

The children in both schools were pretested using the Inquiry Skill Measures in order to determine their initial proficiency with respect to the four inquiry skills of observation, inference, verification, and classification. All of the post laboratory discussions were recorded and analyzed using the Classroom Observational Record in order to be sure that the two discussion techniques were being applied similarly by the two teachers in both schools, and also were being applied as they were defined. The teaching sequence consisted of pre-laboratory instructions, laboratory work, and a post laboratory discussion. All eight classes, four in each school, received identical pre-laboratory and laboratory experience and differed only with respect to the type of post laboratory discussion. At the end of the three month instructional period the children were again tested with an alternate form of the Inquiry Skill Measures. The pretest and posttest scores were analyzed using correlated t-tests and analysis of variance of difference scores.

Analysis of the pretest and posttest data indicated that despite a 29 point IQ difference between the two schools (82 and 111 respectively) there was no significant difference, at the 1 percent level, between the two schools on any of the inquiry skills. The four inquiry skills as measured by the Inquiry Skill Measures were not significantly related to a traditional measure of intelligence.

Both the probing and the non-probing discussion techniques resulted in significant increases in the number of observations made, but neither technique was significantly more effective than the other. The probing discussion was significantly more effective for developing the skill of inference formation than the non-probing discussion. The children exposed to the probing discussion made significantly more inferences, and significantly more accurate inferences, than the children receiving the non-probing discussion. The discussion techniques did not have significantly different effects on the skills of verification and classification.

The study indicated that the initial ability with respect to the four inquiry skills, and the degree of development of these skills, is not significantly related to traditional IQ. It also indicated that a probing type of discussion technique is more effective for developing the frequency and accuracy of inferences than is a more didactic or non-probing discussion.

DIFFERENTIAL RESPONSE TO STRUCTURE OF ADVANCE ORGANIZERS IN SCIENCE INSTRUCTION

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and
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In an experiment designed to investigate individual differences in learning from written materials preceded by advance organizers, 89 fourth grade Ss were randomly assigned to three groups. Two variations of an advance organizer and a control passage preceded an instructional program on insects in which the frames were randomly ordered. Ss received either: an advance organizer providing both high level generalizations and specific examples; one providing high level generalizations but no examples; a control passage which did not include any organizing characteristics.

Prior to instruction Ss were administered aptitude tests representing verbal comprehension, analogies, visual memory for words and delayed recall. Factor tests used were subtests of the CTMM. I.Q. scores were also available with the mean I.Q. for the subject pool being 118.3.

Criterion performances included: multiple choice and matching posttests and retention tests. A 3 X 3 repeated measures ANOV on the multiple choice pretest, posttest and delayed retention test showed significant improvement from pretest to posttest and retention test for all groups ($p<.01$). However, differences between groups did not attain significance.

Similarly a 3 X 2 repeated measures ANOV on the matching posttest and retention test showed significant within group improvement ($p<.01$) from posttest to retention test. Between group differences approached significance ($p<.08$) with Ss receiving both generalizations and examples preceding instruction performing better than the other treatment groups.

Sample linear regression analysis was used to examine the relationship between aptitudes and pretests with the criterion variables. Specific predictions, though tentative, were based on theoretical considerations which suggested that the treatment requirements were sufficiently different to produce different ability - performance relationships. Aptitude X treatment interactions were evaluated by comparing regression slopes for different treatments using F-tests for heterogeneity of regression. Here program errors interacted significantly with I.Q. ($p<.05$) and time spent on the multiple choice test interacted significantly with sex ($p<.05$). Both I.Q. and verbal comprehension scores were significantly related to performance on the matching posttests for the control group ($p<.001$) but not for the experimental group. This relationship was also found between I.Q. and the matching retention test ($p<.01$).

The results obtained in this study appear to be consistent with earlier research on both programed instruction and advance organizers where extremely able Ss have been found to perform well with randomly ordered programs, hence, the strong performance of both the experimental and control groups on the criterion measures. The relationships described for I.Q. and verbal comprehension suggest that the advance organizer treatments appeared to provide the structure for lower I.Q. Ss, that high I.Q., verbally astute Ss were able to provide for themselves. Thus, the use of different types of advance organizers might well be determined by specific learner characteristics.

The results obtained in this study appear sufficiently encouraging to suggest the potential value of further research evaluating differentiation of instruction in both the preparation of science curriculum materials and the subsequent use of them. Results such as these, if replicated, may eventually provide a basis for individualization of instruction in science by structuring both materials and teaching methods with student aptitude characteristics in mind.

AN EXPERIMENTAL INVESTIGATION OF THE EFFECT OF PERFORMANCE CLASS ON THE RATE OF ACQUISITION OF PROCESS BEHAVIORAL OBJECTIVES

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Underwood (1) and Kimble (2) have suggested the use of behavioral definitions in categorizing learning objectives. Data collected by Walbesser and Carter (3) have supported the hypothesis that categories of behavioral objectives exist. The categories have been named performance classes by Walbesser (4) who has defined the classes in terms of the behavioral performance required by the learner. Four examples of performance classes are: Identify, Demonstrate, Construct, and Describe. Two dependent variables are suggested to consider any possible variance between the hypothesized categories of behavioral objectives. The two variables selected are rate of learning and rate of forgetting. A review of learning and forgetting rates dating to 1885 and the work of Ebbinghaus is reported in McGeoch (5). A more recent review through 1970 on learning and forgetting rates is reported by Tulving (6). These two reviews have identified many characteristics of learning materials which effect rates including meaningfulness, student familiarity with materials, similarity of items presented in addition to pictorial representation of material, as well as other factors. The paired associate learning model suggested by Ebbinghaus (7) has been used extensively in the literature to obtain research data on learning and forgetting rates. This study acts to supplement research evidence already accumulated on rates of learning and rates of forgetting, in addition to supplementing the research of Engel (8), Cook (9), and Walbesser and Carter (10) on characteristics of the behavioral objective.

The hypotheses to be tested in this study are the following:

1. Students who receive individually paced instruction acquire performance class objectives, in the classes Identify, Construct, Describe, and Demonstrate at different rates, as indicated by number of time periods.

2. Students who receive individually paced instruction acquire the four types of performance class objectives in the following rank order (from minimum to maximum rate)as indicated by the number of time periods: 1) Identify, 2) Construct, 3) Demonstrate, 4) Describe.

3. Students who receive individually paced instruction forget performance class objectives in the classes Identify, Construct, Demonstrate, Describe at different rates.

4. Students who receive individually paced instruction forget the four types of performance class objectives in the following rank order (from maximum to minimum rate) 1) Construct, 2) Describe, 3) Demonstrate, 4) Identify

The results of the hypotheses tested will be reported in the paper.

The analysis of variance technique will be used to test for significant differences between rates of acquisition and forgetting for the different performance classes. The L-Statistic will be used to test the hypothesized rank order of learning and forgetting rates. The behavioral objectives to be taught are randomly drawn from part D of the Elementary school science program, Science - A Process Approach. The four categories of performance selected for this study include Identify, Construct, Demonstrate and Describe. Fifth grade pupils (120) from a rural Maryland school system have been chosen randomly for this study. The behavioral objectives to be taught are learned through an individually paced learning sequence designed by the researcher. There are three behavioral objectives in each category of performance with 10 students randomly assigned to each behavior making a total of 30 students in each category. Below is a diagram of the student assignments in their respective performance categories.

Performance Class: Identify			
Behavior A 10 Students	Behavior D 10 Students	Behavior G 10 Students	Behavior J 10 Students
Behavior B 10 Students	Behavior E 10 Students	Behavior H 10 Students	Behavior E 10 Students
Behavior C 10 Students	Behavior F 10 Students	Behavior I 10 Students	Behavior L 10 Students
30 Students	30 Students	30 Students	30 Students

The results will indicate whether there is a significant difference in the time needed for a student to acquire a performance in one category as compared to another. With this information a teacher and curriculum planner can be aware in scheduling certain activities that perhaps a greater amount of time will be needed for a lesson in which construction is required as compared to an identifying activity. Also, differences in rates of forgetting would have similar implications for the curriculum designer over an extended period of time. Perhaps a student will forget a describing activity much more readily than a demonstrating activity.

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THE INQUIRY SKILLS MEASURES

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The purpose of this paper is to describe an instrument designed to measure four cognitive skills and to supply data regarding its reliability and validity. These cognitive skills are defined as follows:

1. Observation - the ability to gather data using the five senses.
2. Inference - the ability to project into an unexplored field from observations in an explored field on the assumption of continuity.
3. Verification - the ability to test the validity of an inference.
4. Classification - the ability to form groups having some common specified observed property.

A basic assumption is that these cognitive skills can be inferred from a child's verbal communications.

This test was used in the study. A sealed box with a number of different colored sticks protruding from it is placed on a table in front of a child. He is asked to examine the outside of the box, using all of his senses, and to tell as much about the outside as he can. The child is then asked what the inside of the box is like based upon those things that he observed about the outside. For each inference made the child is asked to give the reason on which he based the inference, and how he would test his inference without opening the box. He is free to give as many independent verifications of each inference as he can. The person administering the test records verbatim the child's statements. The child's ability to classify is measured by presenting him with nine different transparent vials containing different amounts of different colored liquids. He is told to place together in groups all of the vials that are alike in some way, using all of his five senses. When the child has formed his group(s), he is asked to state the reason for his grouping. There is no time limit for any section of the test. An accuracy and frequency score is obtained for each cognitive skill.

Two alternate forms of the ISM were constructed so as to be parallel in form by keeping the shape of the box and vials the same, but changing their colors and contents. To determine if the two forms of the test were equivalent, a group of sixth grade children (100) from an urban school and a suburban school were selected at random and given each form of the test five weeks apart. A three factor (Testor, Sequence, and Form) repeated measure ANOVA was performed to study the effects of these factors on the ISM scores. No significant main effect or interaction was found. The calculated reliability coefficients for parallel forms ranged from .44 to .71. In a separate study the ISM was used in a test-retest situation with two types of instruction intervening between testings; the resulting test-retest reliability coefficients ranged from .39 to .60.

Three pieces of evidence will be offered to answer the validity question. The first is judgemental in nature and is concerned with preparation of the items. This was accomplished with the advice and assistance of people active in the field of science education. All of the parts were pretested on sixth grade children in an effort to ascertain their appropriateness for inclusion in the final form. The second piece of evidence is emperical and judgemental in nature, and involves a factor analysis of the obtained scores. Four factors were isolated; one each associated with cognitive skills of verifying, inferring, and classifying; and one associated with frequency scores. The third piece of evidence is emperical in nature. The ISM was used to detect differences in groups which were taught by two methods purportedly developing these same inquiry skills.

A measure has been developed with a reliability sufficient enough to detect group differences in the use of four cognitive skills supposedly taught in the newer elementary science programs.

CLASSROOM VERBAL BEHAVIOR AS RELATED TO TEACHERS' PERCEPTION OF PUPILS IN FIFTH-GRADE SCIENCE CLASSES

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The major objective of this study was to determine the relationship between the teacher's perception of his pupils and classroom verbal behavior in fifth-grade science classes. The rationale was based on Combs' notion that the ways in which a helper perceived other people and their behavior influence the helper's relationship with those people.

An adjective checklist (Perception of Pupils Adjective Checklist) was used to measure the teachers' perception of pupils. Thirty-four inner-city and thirty-eight outer-city fifth-grade teachers in a large Midwestern city responded to the checklist. From this parent population, ten inner-city teachers--five who had among the highest scores (positive perceivers) and five who had among the lowest scores (negative perceivers)--were selected for observation. A similar group of outer-city teachers was also selected. Approximately 100 minutes of verbal interaction was recorded for each teacher using the Flanders Interaction Analysis system (FIAC).

There were a number of characteristics that statistically distinguished the teachers who were positive perceivers from those who were negative perceivers. Positive perceivers:

1. made greater use of the pupils' ideas.
2. criticized less and made less use of their authority.
3. had more verbal participation from their pupils.
4. exhibited more flexibility in their teaching by using predominately indirect influence during some activity and predominately direct influence during other activity.

Negative perceivers:

1. made greater use of restrictive verbal behavior.
2. used routine questions, directions, and criticism separately or in combination with each other to control the pupils' action.

Generally, teachers who had a positive perception of their pupils used indirect teacher influence, while teachers who had a negative perception of their pupils used direct teacher influence. This study indicates that there is a positive relationship between positive perception and indirect teacher influence.

Flanders and other investigators have generally found a positive association between indirect teacher influence and pupil growth. There is, therefore, a suggested link between the teacher's perception of his pupils and pupil growth.

School context was related to the pupils' verbal participation. In the outer-city classrooms, pupils initiated more talk and talked for longer periods of time than did pupils in inner-city classrooms. The learning conditions under which pupils worked also influenced classroom verbal behavior. When pupils were using materials in activity which was teacher initiated, the teacher used significantly more direct verbal behavior. However, pupil-initiated activity in combination with use of materials resulted in the converse pattern of interaction. Under these learning conditions the interaction was characterized by increased indirect teacher influence and pupil participation. Inner-city classrooms had significantly more pupil-initiated activity and greater use of materials than outer-city classrooms.

Session IVc - Secondary School Science--Enrollments and Curriculum Evaluation

Chairman: Roger G. Olstad, University of Washington, Seattle, Washington.

1. "Development and Validation of a Process Instrument for High School Physics," Maria B. Penny, and J. David Lockard, University of Maryland, College Park, Maryland.
2. "Effectiveness in Learning Newton's Second Law of Motion in Secondary School Physics Using Three Methods of Learning," H. Bruce Geiger, Tamaqua Area School System, Tamaqua, Pennsylvania.
3. "Grading Severity and Enrollments in Secondary School Science," Robert G. Bridgham, Stanford University, Stanford, California.
4. "An Analysis of Published Evaluations of PSSC," Samuel Strauss, The John Hopkins University, Baltimore, Maryland.
5. "Critical Thinking as Related to PSSC and Non-PSSC Physics Programs," Robert H. Poel, Western Michigan University, Kalamazoo, Michigan.
6. "Sex Education Knowledge, Verbal Interaction, and Attitudes: An Exploratory Study in High School Human Biology Classes," Robert C. Wallace, Reavis High School, Oak Lawn, Illinois.

DEVELOPMENT AND VALIDATION OF A PROCESS INSTRUMENT FOR HIGH SCHOOL PHYSICS

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One of the trends to emerge from the sweeping curriculum reforms which science education has undergone since 1957 is the increased emphasis on the duality of science as both a body of knowledge and as a group of processes by which scientists investigate the natural world. The above processes are a series of actions or operations which allow the observer to record events systematically and to interpret them in terms of laws ant theories. This study involved the preparation of a measure to evaluate, for a unit in a high school physics course, those objectives dealing with the behaviors to be acquired by the students.

The study consisted of six phases: identification of the processes, selection of those to be tested, construction of the instrument, administration in a pilot study, test revision and validation of the revised instrument.

The unit chosen was Unit 1 of the Physical Science Study Committee's course, Physics. During phase one, to identify the processes the student had to acquire to successfully complete the tasks assigned him, the following materials were examined:

1. the laboratory experiments
2. the problems at the end of the ten chapters
3. the examinations prepared by the Educational Testing Service
4. the model solutions in the Teacher's Guide

The investigator performed the activities required of the student in the first three sources, defining behaviorally the process being performed. The solutions from the Teacher's Guide were also analyzed to determine processes involved in the model solutions. Eighty-nine processes were identified in phase one.

Phase two involved the selection of a subset of processes to be tested. Two selection criteria were employed. The process appeared at least three times in the unit. Furthermore, the process either exemplified the PSSC approach, or it was necessary for the continued study of physics. Forty processes met the two criteria.

In the third phase, an instrument was constructed to evaluate the forty processes. Items involved mathematical manipulations, data-gathering activities and analysis of given data. During the pilot study, the test was administered to nine classes of PSSC students. The responses then underwent analysis to calculate item difficulties and point biserial correlations for each item. From this analysis, suitable items were identified, and a final version of the instrument was constructed.

The final version is being administered to ten classes of PSSC students. Analysis of the results will consist of calculation of a reliability coefficient and a multiple regression analysis of effects on individual differences on student performance.

The importance of the study lies in the emphasis it places on measuring all the course objectives in contrast to present practice, stressing testing of the content matter only. It may also increase student motivation by placing comparable weight on performance as well as on recall and application of knowledge. Finally, it will be of help in formulating course objectives, since it will necessitate the preparation of behavioral descriptions of processes. This will enhance the teacher's awareness of the objectives for which he is teaching.

EFFECTIVENESS IN LEARNING NEWTON'S SECOND LAW OF MOTION IN SECONDARY SCHOOL PHYSICS USING THREE METHODS OF LEARNING

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This study was designed to determine the relative effectiveness of inductive programed instruction, deductive programed, and the lecture-question approach in learning content, problem-computational ability, and retention of content related to Newton's Second Law of Motion. Programed learning was selected because both the inductive and deductive approaches could be better controlled. Also, the other variables, time of instruction, feedback to responses, and reading level could be controlled. Two null hypotheses based on the evidence or lack of evidence were tested. In addition, the design attempts to determine what correlation exists between both students' attitudes relative to the instructional method used and students' interest in science with their retention gain.

Two hundred sixty-six students from three schools located in Eastern Pennsylvania participated in the study. Three physics classes of nearly equal size were selected in each school to use either the inductive programed instruction, deductive programed instruction or lecture-question approach (control). Students were compared for intelligence and aptitude by scores on the California Short-Form of Mental Maturity and the numerical ability and verbal reasoning sections of the Differential Aptitude Tests. These data were analyzed by using an analysis of variance involving 3 x 3 x 3 factorial experiment. Coefficients of correlation were computed between I.Q. scores and raw scores on Differential Aptitude Tests with retention gain on the test of Newton's Second Law of Motion.

Both null hypotheses are supported. At the .01 level no significant difference in gain to recall factual information, to solve mathematical problems, and to retain facts related to students having different I.Q. scores or when instructed by any one of the instructional methods. At the .01 level, no significant difference in gain to recall factual information, to solve mathematical problems, and to retain facts related to Newton's Second Law of Motion is shown for secondary school students having different numerical ability or verbal reasoning aptitute scores and instructed by one of the instructional methods.

No significant difference in gain to recall factual information, to solve mathematical problems, and to retain facts related to Newton's Second Law of Motion is shown, at the .01 level, for secondary school students having different levels of motivation in science or disliking any one of the instructional methods.

It appears that in teaching the multi-concept physics principle, Newton's Second Law of Motion, any one of the three instructional methods tested produces a mean gain for learning facts, solving mathematical problems and retaining facts not significantly different from the other two.

GRADING SEVERITY AND ENROLLMENTS IN SECONDARY SCHOOL SCIENCE

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A model of the relation between severity of grading and enrollments in the sciences **was** presented:

> As a student progresses through high school he stays in or opts out of a "science-taking" pool. The student's decision to stay in the pool is determined in part by his expectation of the severity of grading in the "next" science course. It is also determined, in part, by his perception of his ability to "do science" which is affected by the severity of his previous grading in science. An appropriate measure of severity of grading is the discrepancy between students' science grades and their grades in other subjects, averaged across students.

This model **was** tested using data on the severity of grading and science enrollments for the class of 1968 in twenty-seven suburban high schools on the San Francisco peninsula.

The degree to which "severity" was a stable characteristic of teacher grading behavior was estimated by comparing data for the class of 1967 and the class of 1968 in seven schools (18 biology teachers and 20 chemistry-physics teachers). Severity was a reasonably stable characteristic for biology teachers (r = .88 between the two years), somewhat less so for chemistry-physics teachers.

Descriptive summaries of the severity of grading statistic indicated that in these school students, on average, receive grades in biology that were comparable to those in their other academic subjects, while in chemistry and physics their science grades tended to be lower than in their other academic subjects. The severity of grading for girls tended to be greater than the severity of grading of boys.

Correlational analyses were reported indicating the relation between severity of grading and enrollment when other factors -- mean academic grade of students, percentage college bound, etc. -- were statistically controlled. One analysis indicated that severity of grading in biology was significantly correlated with the percentage of biology students going on to take chemistry after the mean academic grade of students was controlled for.

AN ANALYSIS OF PUBLISHED EVALUATIONS OF PSSC

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Examination of published research reports indicate that too many studies are poorly planned, badly executed and not adequately reported. The usual brief reviews and annotations are too cursory to reveal the strengths and flaws of published research. Far more thorough critiques, worth the extra effort, can be obtained by using my "Guidelines for Analysis of Research Reports" (J. Ed. Res. 63:165-169, Dec. 1969), which consist of the following fairly rigorous set of twenty criteria: problem raised, previous work cited, objectives stated, hypotheses formulated, assumptions made, population studied, sample drawn, instruments used, design examined, procedure followed, safeguards taken, observations recorded, findings assembled, statistics interpreted, conclusions reached, implications discussed, limitations recognized, further work projected, improvements suggested and clarity of report.

By application of the Guidelines, I have prepared a review chart of four published papers dealing with evaluation of the PSSC curriculum. The chart, which constitutes the body of this paper, consists of a side-by-side comparison of the four studies, according to each of the twenty criteria, and pinpoints the strong and weak features of each evaluation.

It seems strange that, after more than a decade and vast expenditure of effort on PSSC, only four published papers could be located of summative evaluations of the PSSC curriculum. Two of these compared student achievement, after training by PSSC vs. conventional physics, on the Cooperative Physics Test; one also used the PSSC Physics Examination. They found that students did best on tests covering materials to which they had been exposed. The two other reports compared PSSC vs. non-PSSC students as to their success on the Test on Understanding Science and found that those trained in traditional physics did as well, or better, than PSSC-trained students. One of the reports is, with minor exceptions, a splendid piece of work but the other three have serious flaws in such aspects as design, sampling, application of safeguards and statistical treatment. Two of the reports also show strong evidence of fudging, with mis-reading of the data reported to draw unwarranted conclusions.

The educational importance of this procedure is that it provides a technique for specific identification of the sound and weak points of research reports, to aid in their evaluation. The Guidelines may also assist in planning and executing future research projects.

CRITICAL THINKING AS RELATED TO PSSC AND NON-PSSC PHYSICS PROGRAMS

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The purposes of this study were to (1) evaluate a paper-pencil test constructed to measure critical-thinking skills using physical-science content, (2) determine the comparative effectiveness of PSSC and non-PSSC physics programs in developing critical-thinking skills, and (3) identify teacher-pupil verbal interaction behaviors that enhance the development of critical-thinking skills.

Data were obtained by testing approximately 1,000 physics students from 27 high schools in southwestern Michigan during the 1969-70 school year with pre- and posttests of critical-thinking skills. The tests used were the Watson-Glaser Critical Thinking Appraisal, Form ZM (WGCTA) and an author-constructed instrument, A Test of Critical Thinking Ability in Physical Science, Form Z. Thirty of these physics classes were also observed and teacher-pupil verbal interaction was recorded using a modification of the Flanders System of Interaction Analysis.

Due to the very large number of hypotheses considered in this investigation, seven questions were formulated that encompassed the specific hypotheses relating to a particular goal. Although different methods were used to answer these questions, the analysis centered around a factorial design. This two-by-three design was used to determine the independent effect and interacting relationships between the independent variables of type of physics program and levels of teacher-pupil verbal interaction behavior on the development of critical-thinking skills.

Principal conclusions of the study were:

1. There was little evidence to support the belief that either the PSSC or the non-PSSC physics program was more effective in developing critical thinking skills.

2. Development of critical thinking skills as measured by the criterion instruments was related to the teacher-pupil interaction behaviors that increase a student's potential for actively participating in the teaching-learning process. These verbal behaviors, generally termed "indirect," promote situations where the student becomes involved in the learning process.

3. Analyses of the data indicated an interaction between the physics curriculum and verbal classroom behavior, and that this interaction was related to the development of

critical thinking skills. The exact nature of the interacting relationships was not determined; however, it seemed necessary to consider more than the singular effect of these variables on the development of critical thinking skills.

4. A linear relationship does not exist between the mean growth scores on each critical thinking test and the verbal behavior of each class.

5. Comparisons between the verbal behaviors of the physics classes that gained the most and least in critical thinking skills indicated that the two groups did not differ significantly in the amount of time spent in those behaviors.

6. There were few significant differences between the verbal interaction behaviors of PSSC and non-PSSC physics classes.

7. Significant differences in verbal behavior were found between classes which were subjectively selected as being more effective and less effective in developing critical thinking skills.

The implications of these findings are clear. It appears that the teacher via his influence on the verbal interaction in the classroom is probably the critical factor in the classroom. Perhaps the current efforts in science education that have produced several new science programs have emphasized too greatly the role of science content and process and too little the function of the teacher and his influence in the teaching-learning process.

SEX EDUCATION KNOWLEDGE, VERBAL INTERACTION, AND ATTITUDES: AN EXPLORATORY STUDY IN HIGH SCHOOL HUMAN BIOLOGY CLASSES

Robert Clayton Wallace
Reavis High School
Oak Lawn, Illinois

The basic purpose of this study was to evaluate factual knowledge changes, amounts of verbal interaction, and attitudinal changes that occurred in the area of sex education with three different groups of high school seniors, in a student-centered environment, at Reavis High School in Oak Lawn, Illinois.

Subjects were composed of: Group I (girls AND boys) = 24; Group II (girls) = 28; and, Group III (boys) = 15.

Hypothesis I, to measure changes in factual knowledge, was tested for Pre to Post I (two-week duration) mean changes; and, for Post I to Post II (twelve-week duration) mean changes. Two test instruments, Sex Knowledge Inventory and A Venereal Disease Knowledge Inventory - both developed by Dr. Gelolo McHugh of Duke University, were evaluated with a t-test for differences between mean changes.

Hypothesis II, to measure amounts of verbal interaction, was evaluated by analyzing six tape transcriptions from the seventh and eighth days of the sex education unit of study by means of Flanders Interaction Analysis.

Hypothesis III, to measure a more liberal change in attitudes, was tested for Pre to Post I mean changes, and for Post I to Post II mean changes. The first test instrument was a Semantic Differential (after Osgood) containing nine noun concepts (Genital Organs, Menstruation, Homosexual, Divorce, Masturbation, Pregnancy, Venereal Disease, Prostitute, and Abortion) with ten corresponding bipolar adjectives (unimportant-important; unmeaningful-meaningful; bad-good; unsuccessful-successful; unpleasant-pleasant; unwise-wise; weak-strong; soft-hard; passive-active; and, slow-fast). The statistical procedures involved factor analysis of each concept which produced individual factor scores, then measuring the mean changes by a t-test for differences between means. The second test instrument was a subjective questionnaire containing seven open-ended questions; this instrument was also analyzed by a t-test for differences between mean changes.

Senior high school seniors in a mixed group (girls AND boys), during a sex education unit of study:

1. Do not learn significantly more factual knowledge than those students in a segregated group (girls OR boys). And, those students in an all-GIRL class do not learn significantly more factual knowledge than those students in an all-BOY class (as measured from Post I to Post II) - with a male investigator.

2. Do have more verbal interaction than those students in a segregated group (girls OR boys). And, those students in an all-BOY class do not have significantly more verbal interaction than those students in an all-GIRL class.

3. Do have a more liberal change in attitudes than those students in a segregated group (girls OR boys). An all-GIRL class, however, retains a more liberal change in attitudes than an all-BOY class (as measured from Post I to Post II) - with a male investigator.

Based on the findings of this study, it would seem that an appropriate way to teach senior high school students a unit in sex education, in a student-centered environment, when a teacher wants a gain in: student achievement; student verbal interaction; and, positive pupil attitudes, would be to have a mixed class (girls AND boys).

Session IVd - Special Reports

Chairman: Hans O. Andersen, Indiana University, Bloomington, Indiana

1. "The Systematic Design of a Model for Utilizing Educational Television in Science Instruction," Paul W. Welliver, Pennsylvania State University, University Park, Pennsylvania.
2. "Manpower Survey: Science Education," Lee A. Dallas, Western Washington State College, Bellingham, Washington.
3. "The Science Supervisor and Educational Technology," Albert F. Eiss and George H. Ziener, National Science Teachers Association, Washington, D.C.
4. "Report on Education and the Environment in the Americas Conference," Kenneth Jerkins, Morgan State College, Baltimore, Maryland.

THE SYSTEMATIC DESIGN OF A MODEL FOR UTILIZING EDUCATIONAL TELEVISION IN SCIENCE INSTRUCTION

Paul W. Welliver
Pennsylvania State University
University Park, Pennsylvania

During the past decade, parallel acceleration in activity has been occurring in the fields of science education and educational television. Efforts to wed these two movements have been sporatic, uncoordinated, and lacking in systematic development. The result has been, in most instances, a product that is deficient in both scientific validity and appropriateness for television broadcasting. The oft repeated promise of the "great potential of television" in education has generally gone unfulfilled.

A firm basis for decision-making relative to the appropriate applications of this powerful communications medium to the improvement of science seemed to require the systematic evolution of a sound, workable model. Development toward such a model has been progressing over the past seven years in conjunction with three instructional projects, each involving different grade levels.

Analysis began on a TV science instructional program in physical science for ninth grade students.

The course, broadcast at the state level, consisted of daily, half-hour television lessons. Participating science classes usually experienced a short introduction to the television lesson and followed the viewing period with questions and review. The broadcast lessons consisted primarily of expository lectures and demonstrations.

Following the formulation of objectives for the course, techniques were designed and tested toward the goal of providing more valid science learning experiences. Resulting revisions in approach and technique were many. Time was provided during televised lessons for classroom questions and discussions. Student materials suggested experiments that could be performed at home. Instructions were provided for bringing common materials to class to use for experimentation during the televised lessons. Detailed instructions were prepared for teachers describing experiments that students could perform in place of viewing televised lessons.

To promote more variety in learning procedures and greater individualization, television lessons which could be skipped without losing the continuity of the course were designated. Individual lessons were divided into three segments of progressively increasing difficulty allowing the classroom teacher to schedule all or parts of her class to participate in those portions of the lesson considered to be most appropriate.

Data collected on the use of techniques such as these revealed noticeable effects. For example, students taking the course with television performed about three times as many experiments as those not using television. Teachers using television performed about three times as many demonstrations as those not employing television. Furthermore, provisions for flexibility in the use of television lessons by different classes resulted in utilization ranging from 32 to 170 lessons per year.

Developed was a model for televised science instruction emphasizing student participation, individual investigation, and flexibility in use. Application of this model to the preparation of TV experiences in the primary grades refined the techniques already developed as well as providing insights into the potential of television as an instrument for effecting educational change.

This expanded model served as background for planning for the use of television at all elementary school grade levels for an entire state. Implementation of these plans is expected to add new dimensions to the model.

MANPOWER SURVEY: SCIENCE EDUCATION

Lee A. Dallas
Western Washington State College
Bellingham, Washington

Recently published journals in the field of education emphasize the overabundance of job applicants and relatively small number of teaching positions. Up to date information concerning the field of Science Education should be available both to those preparing a career in the field as well as those who would propose new programs. Therefore, in an attempt to update some of the data reported by Rutherford and Watson in the _Journal of Research in Science Teaching_ in 1963, a ten question survey was designed to collect information related to the following areas of concern: (a) the identification of institutions offering doctoral programs in the field of Science Education, (b) establishing enrollment figures for graduate students and recent doctoral graduates in the field, and (c) the identification of proposed areas of future employment. The questionnaire also identified the person serving as Science Education chairman or coordinator

The parameters of the population were established as those schools which offered a doctoral degree in education as reported in _American Universities and Colleges, 10th Edition_. Each of the one hundred and twenty-one schools so listed was sent a copy of the questionnaire. Of this total, ninety-four percent returned a completed copy. Responses related to the number of schools offering doctoral programs in the field of Science Education are summarized in Table I.

TABLE I

Total Schools Offering Doctoral Programs in Science Education*

	Yes	No	Blank
Institutions housing a department of Science Educ.	30	82	2
Institutions offering a doctoral degree in Science Educ.	40	63	11
Institutions offering a doctoral degree with a major or concentration in Science Education	66	41	4

*note - not all columns add up to the same total as some forms were returned with blanks. Blank spaces were not tabulated as zeros.

The second area of concern was with enrollment figures for graduate and recently graduated doctoral students in the field of Science Education. The total number of students currently enrolled in graduate courses leading to a doctoral degree in Science Education or with a major or field specialization in Science Education was calculated to be 1,204.

Of this total, 211 were reportedly completing course work which would "...emphasize science education for the elementary school." A somewhat larger total of 744 were reported to be preparing a background which would "...emphasize science education for the secondary school." Although the questionnaire did not pursue other possible preparation emphases, 94 students were reported to be involved in a K-12 program and 22 were enrolled in a college preparatory program. The total number of "...doctoral degrees in Science Education or emphasizing Science Education..." awarded in 1969 was reported to be 21[illegible]. Respectively when asked to predict degree completion for 1970 the total was calculated to be 239.

TABLE II

Science Education Graduate Enrollments and Specializations

Total doctoral degree enrollees	1204	
Preparation emphasizing elementary science education		211
Preparation emphasizing secondary science education		744
Preparation emphasizing K-12 science education		94
Preparation emphasizing college science education		22

The third area of focus is related to proposed areas of future employment. Editorially one might note that the suggested list of field specializations was not intended to be either inclusive or exclusive. Table III gives the total number of responses reported for each category. As respondees had the opportunity of selecting more than one area, the total responses varies from the total reported graduate enrollees above.

TABLE III

Declared Field Specialization in Which Enrollee Will Seek Employment

1.	Regional Educational Laboratories	6
2.	Teaching College Science	32
3.	Teaching Science Education at College Level	59
4.	Teaching at the Junior College Level	23
5.	Department Heads at Public Schools	15
6.	Public School Science Consultants	31
7.	Curriculum Development Specialists	22
8.	Test Development Specialist	0
9.	Advisory Service Overseas	2
10.	Science Museum Specialists	2
11.	Publishing Company Science Editor	2
12.	Other	8

The data reported here should provide some approximation of the current status of the manpower in Science Education at the doctoral level as of the spring of 1970. The author should like to emphasize that many of the returns listed approximation figures and therefore the totals should not be considered as absolutes. Further, since no attempt was made to define science education or science educator, each of the respondents replied from his own relative bias.

Recommendations for an extension of this study have been favorably received by many professional science educators. Tentatively titled, Science Education Research Manpower, and co-sponsored by the National Association for Research in Science Teaching and the ERIC Information Analysis Center for Science and Mathematics Education at Ohio State, a more extensive and detailed survey is in preparation.

THE SCIENCE SUPERVISOR AND EDUCATIONAL TECHNOLOGY

Albert F. Eiss
and
George H. Ziener
National Science Teachers Association
Washington, D. C.

Educational technology, as the process of curriculum development and the implementation of learning, provides many techniques that can be useful to the science supervisor. The National Science Teachers Association has completed a project, supported by the U.S. Office of Education, in which the responsibilities of science supervisors were thoroughly analyzed, and in which educational technology--as the process of planning and utilizing learning materials--was used to explain what educational technology is and how it may be used in educational systems.

The paper (or more appropriately, the presentation) will be an illustrated explanation of the project and the process by which it was developed.

Information regarding the materials and how they can be obtained and utilized will be presented.

The materials utilize three media: sound tapes (reel-to-reel or cassettes), filmstrips, and printed materials. These media were chosen because they are available to almost every teacher. The materials consist of an introductory package, and four other sets, or packages, any of which may be used independently of the others. Used together, they provide a fairly broad treatment of the role of the supervisor, a description of educational technology, and suggestions for the supervisor in the use of the process of educational technology in working more effectively with teachers and administrators.

The Introductory Package includes a tape-film strip that defines educational technology as the process of developing techniques to facilitate learning and utilizing these techniques in instruction. A second tape-film strip emphasizes the importance of the learner and the need for individualizing the learning process in education. In addition, the package provides printed materials and pre-and post-assessments and describes the four remaining sets of materials. The individual using the introductory set of materials will obtain a definition of educational technology and an understanding of the importance of the individual in the learning process, and will know what is contained in the remaining materials.

The remainder of the materials consists of four sets that may be used independently of each other. These sets deal with (1) the nature of educational technology and its use in the educational system; (2) the supervisor and his work; (3) developing an inservice education program as an example of the application of educational technology to a specific problem; and (4) information about individualizing instruction that provides a practical approach to developing an individualized learning package.

Each of these sets may be used independently of the others, but together they give a broad overview of the responsibilities of a supervisor and ways in which educational technology can assist him in his work. The materials present an approach to learning that is not always used in education: applying the instructional techniques that are advocated for a learning situation, instead of merely talking about the process. The techniques by which the materials were developed show promise of being useful in many other situations and should be considered by educators in dealing with problems of a similar nature.

REPORT ON EDUCATION AND THE ENVIRONMENT IN THE AMERICAS CONFERENCE

Kenneth Jerkins
Morgan State College
Baltimore, Maryland

This conference involving a substantial number of NARST members concerned itself with the role that environmental education should play in the education of teachers. The conference was attended by 78 delegates from Latin America, 150 delegates from North America, and 15 delegates from other countries. Recommendations developing from this conference will be published in English by the American Association of Colleges for Teacher Education and in Spanish by the Organization of American States. The publication, available in May of 1971, can be obtained by writing to AACTE Publications, One Dupont Circle, Washington, D.C.

Session IVe - Symposium----------Fallout from a National Curriculum Project

Chairman: Herbert D. Thier, University of California, Berkeley, California

Participants:

Chester Raun, Temple University, Philadelphia, Pennsylvania.

Robert Karplus, University of California, Berkeley, California.

John W. Renner, University of Oklahoma, Norman, Oklahoma.

Herbert D. Thier, University of California, Berkeley, California.

GENERAL SESSION

Chairman: Frank X. Sutman, Temple University, Philadelphia, Pennsylvania

Speaker: Paul DeHart Hurd, Stanford University, Palo Alto, California.
"The 1970's and the Potential of NARST"

Concurrent Sessions V

Session Va - Elementary School Science--Concepts, Attitudes and Performance

Chairman: Wayne W. Welch, University of Minnesota, Minneapolis, Minnesota

1. "An Investigation of the Relationships Among Selected Attitudinal-Personality Characteristics and Success of Teachers in Installing Science--A Process Approach," Charles W. Wallace, Eastern Regional Institute for Education, Syracuse, New York.
2. "A Comparative Study of Three Fifth Grade Classrooms on Selected Piaget Type Tasks Dealing with Science Related Concepts," Ronald W. Cleminson, Memphis State University, Memphis, Tennessee.
3. "The Role of Classification Skills in Children's Acquisition of Concrete Operational Thought," Theodore Colton, Georgia State University, Atlanta, Georgia, and David Butts, The University of Texas at Austin, Austin, Texas.
4. "The Impact of Atmospheric Pressure Upon Pupil Performance," Carlton W. Knight, II, University of Delaware, Newark, Delaware.
5. "Misconceptions of Selected Science Concepts Held by Elementary School Students," Rodney L. Doran, State University of New York at Buffalo, Buffalo, New York.
6. "Life-Science Concept Development Among Beginning Kindergarten Children from Three Different Community Settings," Donald E. Riechard, Emory University, Atlanta, Georgia.

AN INVESTIGATION OF THE RELATIONSHIPS AMONG SELECTED ATTITUDINAL-PERSONALITY CHARACTERISTICS AND SUCCESS OF TEACHERS IN INSTALLING *SCIENCE--A PROCESS APPROACH*

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There is a dearth of information on factors which serve to inhibit or facilitate the installation of an innovative curriculum into a school. The success of the installation of an innovation must be judged in terms of the adequacy of the implementation. With some programs such as *Science--A Process Approach* one simple method of partially evaluating the adequacy of the installation is to determine the number of exercises taught by a teacher during a school year. A second criterion is to measure the achievement of the students on the competency tasks. Specifically, this study attempts to uncover variables among a number of teacher characteristics and teacher perceptions of the school environment which contribute to the degree of success of installation of *Science--A Process Approach* as measured against the criterion variables of number of *Science--A Process Approach* exercises the teacher has taught and pupil achievement on the competency measure administered by the teacher at the completion of each exercise.

Data were obtained from 288 kindergarten through fourth grade teachers, and the pupil in their classes, from 21 elementary schools distributed throughout New York and Pennsylvania using *Science--A Process Approach*. Three commercially available inventories were utilized to gain information on teacher perceptions and characteristics; the *Purdue Teacher Opinionaire* (PTO), the *Organizational Climate Index* (OCI), and the *Stern Activities Index* (AI). A competency measure card form was developed to collect criterion information on number of exercises taught and pupil achievement.

The multivariate design includes 34 predictor variables obtained from the PTO, OCI and AI instruments plus the two criterion variables. Analysis of the relationship among factors of the predictive instruments was conducted to check independence of study variables. Concurrently, an intercorrelation matrix was obtained for the predictor variables and each of the criterion variables. These correlation matrixes are used in developing full multiple regression equations. Full predictor models have been analyzed to determine if they predict number of exercises and pupil achievement better than the highest zero order correlation. The individual contributions of the predictor variables toward the prediction of the two dependent variables is analyzed using a step-wise multiple regression procedure.

Teacher satisfaction with factors indicative of school morale, perception of school climate and certain personality traits were found to be related to the successful installation of *Science--A Process Approach*. Teachers who taught a substantial number of exercises are characterized by orderliness (maintaining a routine, organized activity patterns, reflectiveness and attention to detail) and other high dependency needs (closeness, timidity, and submissiveness).

These teachers also perceived their school as having adequate supplies and facilities and as offering a school program where teacher reactions are solicited on curriculum issues and the school program is meeting student needs. High pupil achievement on the competency tasks was found to be positively related to the school intellectual climate. Generally, the more verbal and aggressive the teacher, the higher the probability that she will be unsuccessful with this curriculum.

The results of the study postulate certain personality and attitudinal characteristics associated with success of a teacher with Science--A Process Approach. Speculation might be raised about whether certain teacher traits might produce better instructors with certain curricula. Predictions of success in the installation of innovative curricula might be made on the basis of school faculty personnel characteristics and climate.

A COMPARATIVE STUDY OF THREE FIFTH GRADE CLASSROOMS ON SELECTED PIAGET TYPE TASKS DEALING WITH SCIENCE RELATED CONCEPTS

Ronald W. Cleminson
Memphis State University
Memphis, Tennessee

Increasing attention has been directed to the child development studies of Jean Piaget and his co-workers. The primary reason for this interest is, there is no other coherent body of research of such magnitude that supports a specific developmental theory of intelligence. Second, the Piaget tasks themselves provide a probative measure of human intellectual development. The purpose of the Piaget tasks is to assess the child's level of logical reasoning ability when confronted with specific problems. Educationally, the tasks should not be used for the purpose of accelerating conceptual learning but rather to provide an individual assessment of children, as well as of curriculum, in the belief that learning and understanding will be improved.

The major problem of this study was to determine if a significant difference existed in the performance of three groups of fifth-grade children, currently involved in different elementary science programs, on selected science related Piaget type tasks dealing with:

I. Interval time (order of succession and measurement).

II. Multiplicative classification.

III. Coordination of perspective.

IV. Conservation of Area.

V. Conservation of Weight.

VI. Conservation of Volume.

The elementary science programs employed in the study were problem method, Science--A Process Approach, and a multi-textbook approach.

The hypothesis tested in the study was:

> H_O: There will be no significant difference in the performance of fifth-grade children from three separate classrooms using different methods to teach science on selected Piaget type tasks dealing with science related concepts.

The pilot study indicated that Task I, due to its lack of vaiability at this age level, was not an appropriate item for the purpose of the study. The remaining five tasks were employed in the basic study (i.e., Tasks II, III, IV, V, and VI).

The subjects were tested in random order; their reactions and responses were carefully observed and recorded on tape for evaluation. Each child was interviewed individually by the writer. All eighty-four subjects were given the five tasks which were scored in a pre-determined manner based on the child's logical reasoning ability, not on a simple "yes" or "no" response.

Because the data were in discrete ordinal categories and a nonparametric test was desired, the chi-square test was selected as the best statistical procedure to use for the purpose of determining the significance of the differences among the three independent groups.

The results indicated that there was no significant difference between the three fifth-grade groups on the selected Piaget type tasks at the .05 level of significance. The hypothesis was not rejected. The only group which was significantly different from the other two groups was group 2 on Task II. That particular elementary science program, Science--A Process Approach, offers students an opportunity to classify objects beginning at the kindergarten level.

In conclusion, it appears that the three elementary science programs, problem method, Science--A Process Approach, and a multi-textbook approach, did not make any major differences in the subjects' performance in logical reasoning on these science related Piaget type tasks.

THE ROLE OF CLASSIFICATION SKILLS IN CHILDREN'S ACQUISITION OF CONCRETE OPERATIONAL THOUGHT

Theodore Colton
Georgia State University, Athens, Georgia

and

David Butts
The University of Texas at Austin, Austin, Texas

There were two purposes to this study: first, to explore the relationship between the ability to perform a concrete operational task at the preoperational level and the acquisition of classification skills based on a systematic task analysis of that specific operational task and, second, to examine the relative effectiveness of a science curriculum based on systematic task analysis on the development of classification skills related to a learner's ability to accomplish a specific task.

In this study the concrete operational task of predicting floating objects as described by Piaget and Almy was used. Based on a systematic analysis of this task a series of ordered skills and processes were developed. This analysis of skills and processes was used to develop behavioral objectives for a series of instructional sequences. The short-term instructional sequences were taught to children in the first-and third-grade, half of whom had had long-term instruction based on Science--A Process Approach, an elementary school science program designed to teach the processes of science by means of lessons based on task analysis and behavioral objectives.

It was found that for both children in the first-grade and the third-grade all groups that had experience in the short-term instructional program made significant gains in their performance of the concrete operational tasks as contrasted with their control counterparts. It was also noted that third-graders who had had long-term instruction demonstrated acquisition of the ability to perform the concrete operational task of predicting which objects will float. A similar relationship for first-grade students was not found.

Given long-term instruction or short-term instruction in classification skills, the results of this study support the conclusion that children can be helped to acquire concrete operational thought which they do not demonstrate when denied such instruction. The design of curriculum must be based on both what is feasible ("what can be") and what is desired ("what ought to be"). While the findings of this study provide assistance with the former, answering the latter requires that the curriculum designer consider what values of the total school and societal setting ougth to be reflected in the curriculum that is implemented by the educational complex. In this study task analysis has been found to be a functional tool in designing curriculum. It is the responsibility of the educator and curriculum designer to decide when to apply this tool of task analysis so that it will be most beneficial to the learner.

THE IMPACT OF ATMOSPHERIC PRESSURE UPON PUPIL PERFORMANCE

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The purpose of this research was to determine the impact of three levels of atmospheric pressure (30.32, 31.88, and 37.17 inches of mercury) on student test performance in mathematics. All pressure variations are within the range encountered in man's normal environment.

The hypotheses were:

1. Testing at three atmospheric pressure levels does not have a differential impact upon student mathematical scores.

2. Interaction between student achievement and the three pressure levels is not significant.

The procedures included stratifying one-hundred-seventeen fifth grade students into high, average, and low achievement classifications using scores on a Portland Elementary School Mathematics Test (PESM Test) given eleven weeks prior to the experiment. The students within each stratification were randomly assigned to nine testing groups. Each groups subsequently completed the PESM Test while the atmospheric pressure was maintained at one of three pressure levels.

Three pressurized testing periods were conducted each day for three consecutive days. A three-by-three rotating schedule permitted testing at each pressure level during each of the three time periods. Uniform procedures required each group to: (1) experience a fifteen minute pressurization period, (2) complete the PESM Test during a seventy-five minute testing session, and (3) experience gradual decompression. The temperature, humidity, ventilation, and lighting within the test chamber were controlled.

The results of a two-way analysis of variance using the PESM Test scores obtained prior to the experiment revealed no significant differences ($p>.05$) in mean mathematical test performance among the three groups to be tested at the three pressure levels (one group at each level) prior to the experiment. A two-way analysis of variance utilizing the PESM Test scores obtained during the pressurized testing session revealed: (1) differences among the means of three groups tested at the three pressure levels were not significant ($p>.05$); and (2) interaction between achievement levels and the three pressure levels was not significant ($p>.05$).

The importance of this research is reflected by the previous attempts to identify those physical elements of the classroom which exert a significat influence on academic performance. Investigations indicate that temperature, humidity, and illumination influence academic performance and that atmospheric pressure is somehow related to observable physical behavior. If pressure affects the physical behavior of students, might it also influence academic performance? This study revealed no influence.

MISCONCEPTIONS OF SELECTED SCIENCE CONCEPTS

HELD BY ELEMENTARY SCHOOL STUDENTS

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The purpose of this study was to determine some of the misconceptions held by elementary school children with respect to selected concepts. The concepts selected for the study were from the particle theory of matter conceptual scheme. This scheme has been the focus of considerable research and was listed by the NSTA publication, Theory Into Action, as an important idea around which K-12 science curricula might be built.

The study involved obtaining student responses to a number of specially designed test items which were of the alternate response type where the distractors represented some possible misconceptions about the concept being tested. For instance, misconceptions concerning the concept "Particles of matter move farther apart as a result of heating" might be: (1) the particles increase in size or, (2) the particles increase in number.

To minimize the reading demands on the students, the choices were represented by pictorial models and the questions were read aloud to the students. Motion was a relevant factor for several concepts; so test items were presented via film. The filmed test items were administered to the students in their regular classroom. The students indicated their response by putting an "X" over $\boxed{A}$ or $\boxed{B}$ on their answer sheet. Directions and sample questions were provided.

Some of the misconceptions to be investigated include: the idea that matter (gas, liquid, and solid) is continuous, the idea that particles of matter increase in size as a result of heating, the confusion between compounds and mixtures, and the idea that motion explains electrical phenomena. The results will be reported in terms of the proportion of children at each grade level chosing responses indicating particular misconception.

LIFE-SCIENCE CONCEPT DEVELOPMENT AMONG BEGINNING KINDERGARTEN CHILDREN FROM THREE DIFFERENT COMMUNITY SETTINGS

Donald E. Riechard
Emory University
Atlanta, Georgia

This study was designed to investigate two basic questions: (1) Do children from three different community settings (inner-urban, outer-urban, and rural-farm) differ significantly in life-science concept development at the time they begin kindergarten; and (2) What physical, mental, and socio-cultural factors seem to be the most useful predictors of life-science concept development among beginning kindergarten children?

A Life-Science Concept Acquisition Test (L-SCAT) containing items distributed among the seven BSCS content themes was developed by the investigator. The L-SCAT was administered individually to each subject as a picture-stimulus structured-interview and was designed to elicit nonverbal and verbal responses. The sample population was composed of fifty-one subjects; seventeen from each each of the three community settings.

Among the results and conclusions were the following: (1) there were significant differences, at the .05 level, among the scores made on each of the L-SCAT measures (verbal and nonverbal) by the subjects of the three community settings; (2) based on subjects' mean L-SCAT scores, the community setting rank-order, from low-to-high, was inner-urban, rural-farm, and outer-urban; (3) subjects' responses seemed to indicate that certain nondisciplinary concepts (e.g. time, likeness, difference, size, change, etc.) are important elements in life-science concept development; (4) when thirty-one physical, mental, and socio-cultural variables were used as predictors, a subject's I.Q. and his chronological age were the first and second most useful variables in predicting both verbal and nonverbal L-SCAT performance; (5) when socio-cultural variables alone were used as predictors, the number of years education of a subject's mother and the presence of younger siblings were the first and second most useful variables in predicting verbal L-SCAT performance; (6) when socio-cultural variables alone were used as predictors, the number of years education of a subject's mother and a subject's community setting were the first and second most useful variables in predicting nonverbal L-SCAT performance.

These results are of particular educational importance to people who have responsibility for planning preschool and primary school science curricula. Sound pedagogical theory dictates that instruction should begin at the child's present level of conceptualization. It seems obvious, therefore, that all available data concerning readiness for science instruction should be considered as important factors in program planning.

Session Vb - Secondary School Science--Programs and Attitudes

Chairman: J. Dudley Herron, Purdue University, Lafayette, Indiana

1. "Societal Issues: The Development of an Attitude Instrument and its Use with Oregon High School Seniors," Robert L. Steiner, The Ohio State University, Columbus, Ohio.

2. "The Measurement of High School Students' Knowledge about Science and Scientists," Glen S. Aikenhead, Harvard University, Cambridge, Massachusetts.

3. "Factors Associated with the Per Cent of Science Instructional Time Spent in Laboratory Investigations in the Maryland Public Secondary Schools," James W. Latham, Jr., Maryland State Department of Education, Baltimore, Maryland, and J. David Lockard, University of Maryland, College Park, Maryland.

4. "A Descriptive Study of Teacher Verbal Behavior in an Inquiry Approach, Laboratory-Oriented Secondary Science Course," Thomas A. Butler, The University of Rochester, Rochester, New York.

5. "An Analysis of the Relationship Between Certain Mathematics Skills and Chemistry Achievement," Rita T. Denny, St. Joseph's College, Philadelphia, Pennsylvania.

6. "Dynamics of the Decision-Making Process in the Adoption of a New Physics Course in American High Schools," John F. Yegge, Harvard University, Cambridge, Massachusetts.

THE DEVELOPMENT OF AN ATTITUDE INSTRUMENT AND ITS USE WITH OREGON HIGH SCHOOL SENIORS

Robert L. Steiner
The Ohio State University
Columbus, Ohio

The present study involved 1) the inductive development of a Likert type attitude inventory to assess attitudes toward identified referents which are basic to specific societal issues such as pollution, population, and conservation, and 2) the assessment of the attitudes of a representative sample of Oregon high school seniors toward the identified basic attitudes.

The development of the instrument was a joint research project; the investigator then assessed the attitudes of the sample of Oregon high school seniors.

Examination of popular and professional literature and other media forms was used to identify a variety of societal issues. A preliminary pool of approximately 250 Likert type items about specific issues was developed and revised based on pilot work with university and high school students. Ambiguities, unfamiliar terms and consensus items were eliminated, and one hundred representative items were selected for the preliminary inventory.

A randomly selected sample of Oregon high school seniors was administered the preliminary inventory. The responses were factor analyzed to identify attitudes basic to the specific societal issues represented in the inventory.

The factor analysis yielded seven interpretable factors consisting of 60 of the 100 items. This instrument was called the Inventory of Societal Issues (ISI). The factors were identified as follows:

1. A general regard for human life and those things which may be detrimental to it.
2. Disillusionment and pessimism regarding the implications and outcomes of the involvement of man with nature.
3. Desire for the conservation and preservation of the environment and natural resources.
4. Concern for the problem of increased population, and the implications or consequences of this increase.
5. Concern for the responsibilities and sacrifices demanded of the individual in order to effectively deal with current social problems.
6. Optimistic belief in the ability and desirability of science and technology to solve societal problems and deal with deficiencies in our environment.
7. Concern for individual freedom and rights.

The representative sample of Oregon high school students were classified as to amount of science, school environment, and sex. The student's scores on each of the factor attitude scales were used as dependent variables, and the student's classification as the independent variable in an analysis of variance. In addition, the science and non-science subgroups were compared by Chi square on all items of the Inventory of Societal Issues.

The amount of science, school environment, and sex were found to be significant on three of the factors. The science and non-science groups were found to respond significantly different on 24 of the 60 items on the ISI.

The present research is important in that a rather unique method was used in the development of the attitude scales. In addition, an instrument was made available for the assessment of those attitudes identified by the factor analysis. Finally, although many societal issues are science related, the amount of science a student took in high school did not result in attitudes significantly different from students who took a minimum of science.

THE MEASUREMENT OF HIGH SCHOOL STUDENTS' KNOWLEDGE ABOUT SCIENCE AND SCIENTISTS

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Testing and evaluation comprise a conspicuous portion of science education. From a student's point of view, an exposure to science is often through the knowledge required for an impending examination, whether administered by his science teacher, state education board, or the Educational Testing Service itself. Is this testable knowledge consistent with our educational objectives?

I suspect that any thoughtful student would find us ambivalent in many cases. They would discover inconsistency between the stated objectives and what objectives are actually tested, predominantly in the realm of scientific literacy. Specifically, I am referring to the objective of learning about science and scientists: the aims of science, its assumptions, its tactics, its interactions with society, its internal institutional mechanisms, and its human needs. Understanding the nature of science is now generally accepted as a major objective of science education.

In research studies, criteria for measuring student learning correspond with widely acknowledged goals of education. Studies that concern the nature of science are a case in point. As with most research, the quantifying of student learning invariably yields data which either support or plunder investigative null hypotheses. It would seem mandatory that serious researchers in this area become aware of a repertoire of relevant evaluative instruments and the conditions under which these instruments have been appropriately applied.

Available instruments that purport to measure knowledge about science and scientists are critically reviewed. (This excludes instruments related to one's ability to engage in scientific processes and instruments indicating one's attitude toward or appreciation of science and scientists.) The paper draws upon research studies for evidence of the tests' applicability, validity, and reliability. This analysis should nurture confidence in otherwise inconspicuous instuments. Furthermore, the paper considers some promising directions for further research.

FACTORS ASSOCIATED WITH THE PER CENT OF SCIENCE INSTRUCTIONAL TIME SPENT IN LABORATORY INVESTIGATIONS IN THE MARYLAND PUBLIC SECONDARY SCHOOLS

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and

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The purpose of this study was to determine the relationship between the per cent of science instructional time spent in laboratory investigations in the Maryland public secondary schools and 48 predictor variables. The predictor variables were classified into four groups: geographic region; science course; laboratory facilities; and science equipment.

All Maryland public secondary schools in operation in the spring of 1968 were surveyed regarding the following: science facilities in the classroom; science equipment available; and per cent of science instructional time spent in laboratory investigations. A total of 997 individual school science courses were analyzed.

A multiple linear regression program was used in determining the predictive contributions of the five models tested. The full model used all 48 predictor variables to estimate the time spent in laboratory investigations. The four restricted models had deleted from them respectively: information about the geographic region, the science courses, the facilities, and the equipment. The unique contributions of the deleted variables were determined as the difference between the predictive contribution of the full model and that of each of the restricted models. These differences were tested for significance with an F-test.

These findings resulted:

1. There was a variance in the per cent of science instructional time spent in laboratory investigations.

2. There was a variance in the per cent of science instructional time spent in laboratory investigations in different geographic regions.

3. There was a variance in the per cent of instructional time spent in laboratory investigations in six different secondary school science courses. Ordered from low to high by time spent in laboratory investigations the courses were: science seven; science eight; science nine; physics; chemistry; and biology.

4. There were differences in the laboratory facilities and quantities of science equipment provided for use in teaching secondary school science. The equipment mode was one set for each two students.

5. Only about two per cent of the variance in laboratory time could be attributed to the science courses being offered in different geographic regions.

6. The relationship between time spent in laboratory investigations and six different secondary school science courses was weak. Only about one per cent of the variance in laboratory time could be attributed to the six different science courses.

7. The differences in laboratory facilities did not contribute significantly to explaining the variance in laboratory time.

8. The relationship between time spent in laboratory investigations and the quantity of equipment available was weak. Correlations between the time spent in laboratory investigations and the quantities of equipment provided increased with the larger quantities of equipment. An equipment ratio of one set for each two students had a higher relationship with the laboratory time than an equipment ratio of one set for each student. Only about seven per cent of the variance in laboratory time could be attributed to differences in the quantities of science equipment provided.

A DESCRIPTIVE STUDY OF TEACHER VERBAL BEHAVIOR IN AN INQUIRY APPROACH, LABORATORY-ORIENTED SECONDARY SCIENCE COURSE

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During the 1960's the philosophical foundations and curriculum development procedures of science education have undergone considerable change. A result of this change has not only the appearance of new courses, but presumably a shift in the role of the teacher from that of an authority and source of information to that of a manager of an inquiry and laboratory-centered learning experience. Little research is available, however, to indicate whether teacher classroom behavior actually corresponds to that which could be considered appropriate and effective in such new courses.

The study summarized here attempted to describe teacher verbal behavior in Introductory Physical Science (IPS), a modern junior high level science course. Primarily, however, it sought to ascertain the extent to which the IPS course is being taught in accordance with the goals and philosophy of its designers. The latter suggest an indirect approach relative to teacher influence, use of indirect questioning, considerable freedom on the part of the students to engage in both intellectual and laboratory exploration, and so forth. Utilizing Flanders Interaction Analysis and a question analysis system based on the work of Aschner and Gallagher, selected affective and cognitive aspects of classroom behavior, respectively, were examined. The study was conducted in the Introductory Physical Science classes of ten teachers, two each from five different suburban Rochester, New York, school districts. The sample consisted of nine males and one female ranging in age from 23 to 55 years, in total teacher experience from one-half to sixteen years, and in IPS teaching experience from one-half to four years.

Audio tape recordings were made in each teacher's classes during the four major instructional activities of IPS, Pre-Lab briefings, Lab work, Post-Lab discussions, and "H. D. and L." problem sessions. For each teacher, two or more different taped segments were combined to yield a thirty minute sample of each of the above instructional activities. A total of two hours of audio tape, therefore, was collected for each teacher. For both selected Flanders data and the question analysis data, the following tables were prepared for analytical purposes: a Grand Composite of all teachers in all activities, and Activity Composite for all teachers, a Teacher Composite for each teacher in combined IPS activities, and four tables containing the data for individual teachers in each of the activities of IPS.

The findings of this study indicate that IPS is not being taught in a manner congruent with the philosophy of this and other modern science courses. The following conclusions were supported by the data:

1. The overall patterns of influence as measured by Flanders I/D Ratios indicate a strongly direct teacher verbal approach.
2. Teacher talk was high, representing from about two-thirds to three-fourths of all verbal activity. As noted, most of this was direct.
3. While the teachers studied praised frequently, they exhibited very little verbal behavior classifiable as acceptance and use of student ideas.
4. There were relatively small amounts of extended student talk.
5. Most of the teacher talk was in the form of narrow questioning and extended lecture.
6. Question analysis data show that over three-fourths of all teacher questions were direct. That is, they were of the cognitive memory, convergent, or procedural type as opposed to the indirect divergent and evaluative types.

These conclusions indicate that teacher behavior patterns as they relate to both the affective and the cognitive domains, are generally inappropriate for the type of course IPS is designed to be.

ALL ANALYSIS OF THE RELATIONSHIP BETWEEN CERTAIN MATHEMATICS SKILL AND CHEMISTRY ACHIEVEMENT

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This research focuses upon the mathematics skills used to perform chemistry problems, attempting to discern the presence of this mathematics competency in the students.

In an analysis of chemistry texts copyrighted between 1960 and 1970, ten mathematics skills were used by all to solve chemistry problems: (1) computation; (2) use of parentheses; (3) signed number usage; (4) use and manipulation of fractions; (5) use of decimals; (6) use of exponents, manipulation of numbers with exponents and logarithm equivalence; (7) use of percentage; (8) manipulation of one-variable equations; (9) use of ratio and proportion; (10) producing and interpreting x,y graphs. Items using these skills were assembled in the Mathematics Skill Test (MAST), using three operationally defined levels of difficulty. Construct validity of MAST was judged by five experts for the nature of the skills used and what level of difficulty each item represented. The 91-item MAST (experimental form) was given to 128 first year high school chemistry students in seven Philadelphia Public Schools, in a 90-minute double class period and these test results served as the basis for item analysis. Based on difficulty and discrimination indexes and skills used, 60 items were selected for MAST (revised form). This revised form of MAST, designed to be given in 45 minutes, utilizes the ten mathematics skills with 14 items at Level I, 32 items at Level II, and 14 items at Level III.

To establish concurrent validity of MAST with the 1969 ACS-NSTA High School Chemistry Test as a criterion for chemistry achievement, MAST was given to 276 first year high school chemistry students in six high schools of the Philadelphia Public School system, producing overall test reliabilities of .963 (covariance) and .967 (K-R #20). Subtest reliabilities for the three levels and ten skills range from .853 to .964.

Of the 80 items of the ACS test, 47 items use one or more mathematics skills. These 47 items were used to form a chemistry-calculations subtest. To establish the presence of a relationship between the MAST test and each subtest, product-moment correlations were computed with overall test scores and calculations subscores of the 1969 ACS-NSTA High School Chemistry Test. The highly significant correlational values produced by this research, rangeing between .633 and .823, indicate the presence of a functional relationship between these ten mathematics skills and chemistry achievement. MAST can be used to diagnose individual student background in the mathematics skills needed for chemistry success prior to student difficulties in chemistry calculations.

DYNAMICS OF THE DECISION-MAKING PROCESS IN THE ADOPTION OF A NEW PHYSICS COURSE IN AMERICAN HIGH SCHOOLS

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This study examines the dynamics of the decision-making process in the adoption of a new physics course -- Project Physics -- in American high schools. The sample of 457 physics teachers, attending 14 Project Physics summer institutes in 1970, was tested with information and attitude questionnaires to evaluate the relationships of a broad selection of variables to the status of adoption of the new course in their schools. The variables examined may be categorized briefly as (1) teacher variables: personal, interpersonal, profession, attitudinal, and perceptual (with regard to the new course); (2) administrator variables: personal, interpersonal, professional, and attitudinal; and (3) school variables.

Chi-square statistics were used to identify variables that appeared to be related to the "status of course adoption." For purposes of this study, the "status of course adoption" was dichotomized into (1) schools which had already (i.e. before September, 1970) adopted the course or will adopt the course by September, 1971 and (2) schools which will delay adoption or not adopt the course at all.

About forty variables were found to be significantly related to the "adoption status" of Project Physics. These variables were factor analyzed into five main categories that appeared to describe (in order of decreasing fraction of total variance explained): (1) the teacher's attitude toward the adoption process; (2) the teacher's perception of physics as important and useful; (3) the amount of the teacher's interaction with colleagues and administrators: (4) the teacher's perception of the guidance counselor as supporting, professional, and important; (5) a composite of personal and professional characteristics of the teacher.

Data were also collected from 98 school administrators attending two-day "implementation conferences" conducted at four of the summer institutes from which teacher data were obtained. These administrators, representing some of the same schools or school systems as teachers in the institutes, were invited to the conferences to provide an administrative perspective on the decision-making process. T-tests were used to (1) compare teacher and administrator perceptions of the adoption process, (2) search for pre- and post-conference differences in both teacher and administrator views of the adoption process, and (3) compare matched pairs of teachers and administrators from the same schools as to their perceptions of the adoption mechanism in their schools.

A guideline for effective adoption and implementation of new science courses, such as Project Physics, is proposed in the light of the conclusions of the study.

Session Vc - Science for the Disadvantaged

Chairman: Fred T. Pregger, Trenton State College, Trenton, New Jersey

1. "The Development of Physical Science Curriculum Materials for Slow Learners and the Effect These Materials Have on Student Attitudes When Used with Average Students With Reading Difficulties," Earl J. Montague, the University of Texas at Austin, Austin, Texas
2. "A Demonstration of an Improved Science Curriculum for Underachieving Students, DISCUS, A Final Report," N. Eldred Bingham, University of Florida, Gainesville, Florida, C. Robert Cronin and Larry J. Paulk, Duval County School Board, Jacksonville, Florida.
3. "A Study to Determine the Effect of Science Inquiry on the Abstract Categorization Behavior of Deaf Children," Sister M. Eunice Boyd, St. Joseph's College, North Windham, Maine.
4. "An Evaluation of the Influence of a Success Oriented Science Curriculum for Underachieving Students on School Attendance," Mildred B. Roberts, University of Florida, Gainesville, Florida.

THE DEVELOPMENT OF PHYSICAL SCIENCE CURRICULUM MATERIALS FOR SLOW LEARNERS AND THE EFFECT THESE MATERIALS HAVE ON STUDENT ATTITUDES WHEN USED WITH AVERAGE STUDENTS WITH READING DIFFICULTIES

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A set of curriculum materials was designed for use with ninth-grade slow learners, here defined as those with a measured I.Q. from 75 through 90 and a reading level equal to or less than the present grade placement. The materials were designed to take advantage of the identifiable strengths and compensate for the weaknesses of this group. In general the materials reflected an emphasis on first-hand, concrete experiences with special consideration given to the students' problems with communication. It was felt that such materials may have a positive effect on student attitudes toward their science classroom experiences.

The problem of this study focused on what effect on attitudes these same materials would have when used with students of average I.Q. and reading levels below present grade placement. Specifically, student attitudes toward the science class, science laboratory, the science teacher, the school, and the topics involved in the materials.

The evaluation design has been designated by Campbell and Stanley as the nonequivalent control group design. Six low achievement classes were selected and three classes randomly assigned to the experimental group and three to the control group. Two teachers taught the experimental classes and two teachers the control classes, with no teachers teaching both an experimental and control class.

Both experimental and control classes were administered a form of the Semantic Differential, as developed by Osgood. Scores on this instrument were collected as pre- and posttests for all individuals in the experimental and control classes. However, only the scores of students conforming to the definition of the average student as set forth in this study, were used in the statistical analysis of the data. Table 1 describes the measured attributes of this group.

Table 1

Description of the Sample (n = 54)

	I.Q.	Reading Level	Arithmetic Level
Range	92-118	4.8-10.3	6.0-10.3
Average	110	8.0	7.6

A DEMONSTRATION OF AN IMPROVED SCIENCE CURRICULUM FOR UNDERACHIEVING STUDENTS, DISCUS, A FINAL REPORT

N. Eldred Bingham
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Gainesville, Florida

and

C. Robert Cronin
and
Larry J. Paulk
Duval County School Board
Jacksonville, Florida

The purpose of the DISCUS Program was to develop and test an improved science curriculum (for economically disadvantaged underachieving junior high school students). The assumption on which this program is based was that if these students are placed in a success-oriented situation in which they carry out elementary laboratory activities in small groups under a directed discovery approach and in which the data generated in these activities is used in developing concepts, their communicative skills and their attitudes toward themselves, their teacher, and the school will improve and they will continue in school instead of dropping out at the first opportunity. The experiences of the Pilot Study in the first two years of DISCUS supported this assumption. This paper reports on the 1969-70 operation and presents a summary of changes during 1968-70. The effect of "instant integration" on attitudes of black and white students will be reported in certain situations.

Though the DISCUS Program was taught by 55 teachers during the past year, the analysis will be limited to the results obtained in the classes of the 30 teachers reported in the 1969 analysis.

The same hypotheses will be tested and reported in this paper that were reported in the 1969 paper: treatment, grade, race, sex or interactions among these factors make no difference in the students' attitudes toward themselves, their peers, their teachers, or their school.

Additional hypotheses to be tested this year are: 1) that treatment, grade, race, sex or interactions among these factors make no difference in the students' cognitive development in science as measured by the STEP test designed for use with 4th, 5th, and 6th grade children and 2) that no differences occurred in the attitudes of the students toward themselves, their peers, their teachers, or their school when "instant integration" took place in certain schools.

Applied Multiple Linear Regression Techniques for use with the computer as developed by Battenburg, Ward, and others will be used in the analysis.

Data are being analyzed at present and hence, a final statement cannot be presented in this abstract.

The pretest was given to both the experimental and control classes before the presentation of the curriculum materials. After a period of thirty-three instructional days, during which the experimental group used the special curriculum materials, both groups were administered the posttest.

The presentation of these physical science curriculum materials improved the attitudes of these students toward their science class and science laboratory. There is also an indication that their attitudes toward their science teacher improved.

Physical science curriculum materials designed for slow learners, using the guidelines established in this study, seem to be effective in improving the attitudes of students of average mental ability who also may have some reading problems.

A STUDY TO DETERMINE THE EFFECT OF SCIENCE INQUIRY ON THE ABSTRACT CATEGORIZATION BEHAVIOR OF DEAF CHILDREN

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North Windham, Maine

Numerous research studies have yielded evidence that the abstract mental skills of deaf children are inferior to those of hearing children. Many psychologists and educators consider this an irremedial consequence of language deficiency and, therefore, direct their efforts toward changing the level of linguistic competence. There is, however, a largely unexplored possibility that the failure of deaf children to attain normal abstract skills is only indirectly related to language deficiency and directly related to restricted experiential stimulation in early life.

The purpose of the study was to demonstrate that the conceptual categorization behavior of deaf children can be altered by specific experiences in the manipulation of objects. Such a statement of purpose implies underlying assumptions: (1) that the abstract thinking processes can operate independently of the cognitive processes of language and (2) that the retardation in the development of conceptual categorization behavior in deaf children is the consequence of experiential restriction.

Students, between the ages of ten and thirteen, at the Archbishop Ryan Memorial Institute for the Deaf, were selected for the study. The subjects' status as language deficient was determined by the combined measurements of hearing loss severe enough to preclude the acquisition of language through speech and reading achievement indicative of inadequate mastery of language as a graphic system. All the subjects were of normal intelligence and had incurred the loss of hearing by the second year of life. The twenty-six subjects, who met the criteria for selection, were randomly assigned to an experimental and a control group.

The Goldstein-Sheerer Object Sorting Test was used for the measurement of conceptual categorization behavior. This test assesses two distinct types of behavior: active categorization, in which a subject groups objects according to his own preferred organizational structures, and compliant categorization, in which a subject identifies the categorical structures of preselected groupings. The cognitive styles underlying categorizations are indicated by the definitions the subject gives for the criteria used for grouping objects. Three cognitive styles are identified by the test--concretistic, functional, and conceptual. Conceptual categorization, as measured by the test, is characterized by the abstraction of intrinsic attributes and essences of the objects grouped.

The pretest-posttest control group design was used. Dual forms of the Goldstein-Sheerer Object Sorting Test were used to minimize pretest influence on posttest performance. A vocabulary test was administered prior to the pretest to establish that the vocabulary achievement of the subjects equipped them with the verbal terms required for the conceptual definitions elicited by the test.

Experimental treatment consisted of participation in thirty thirty-minute sessions of science inquiry, structured toward the development of classificatory skills, and based on the physical manipulation of objects. The control group participated in the regular science curriculum of Ryan Institute for an amount of time equal to that of the inquiry sessions.

The research data were analyzed by between-group and within-group t tests of the difference between the means of pretest and posttest scores and by an analysis of variance for a two-factor experiment with repeated measures of one factor. All statistical analyses indicated a significant difference between the pretest and posttest conceptual categorization behavior of the experimental group. The results supported the rejection of the null hypothesis that participation in specific science inquiry will cause no significant change in the abstract categorization behavior of deaf children. The statistical analyses of the research justified the conclusion that the conceptual categorization behavior of deaf children can be altered by specific experiential enrichment.

AN EVALUATION OF THE INFLUENCE OF A SUCCESS ORIENTED SCIENCE CURRICULUM FOR UNDERACHIEVING STUDENTS ON SCHOOL ATTENDANCE

Mildred B. Roberts
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Gainesville, Florida

The purpose of this study was to measure the relative success of the DISCUS project in terms of resultant behavioral changes in student attendance.

Attendance was studied as voluntary for students over 16 years of age, involuntary for students under 16 years of age. Attendance and participation in extra-curricular activities was considered as well as academic attendance.

The attendance records of students enrolled in the experimental and control classes of the DISCUS project were obtained from the student's permanent record folder.

The average attendance for the Jacksonville schools was obtained from county records.

The co-curricular activities' attendance was obtained from a questionnaire.

No significant difference was found between the attendance of the experimental and control classes when the students were in 7th grade.

Again no significant difference was found when these students were in eighth grade although a trend of more absences in the control classes was found.

When the students finished the ninth grade a significant difference was found. The modal student in the control group had twice the number of absences that the modal student of the experimental group had.

This study evaluated a compensatory curriculum's effect on attendance over a period of three years.

This same method of evaluation can be used to evaluate other curriculum projects.

Session Vd - Symposium----------The Role of Learning Theory in Science Education

Chairman: Joseph D. Novak, Cornell University, Ithaca, New York

Participants:

"Learning Achievement and the Efficiency of Learning the Concept of Vector Addition at Three Different Grade Levels,"Allan Gubrud, Lane Community College, Eugene, Oregon.

"Factors Affecting Achievement in College Chemistry,"Donald G. Ring, Wheeling High School, Wheeling, Illinois.

"Audio-Tutorial Instruction and Children's Cognitive Growth in Elementary Science,"K. Michael Hibbard, Gerald Friedman, Joseph Nussbaum, Cornell University, Ithaca, New York.

"Analysis of Science Concept Attainment, Grades K-6,"Alan Voelker, University of Wisconsin, Madison, Wisconsin.

Summary and Reactions , Joseph D. Novak, Cornell University, Ithaca, New York.

Session Ve - Symposium----------A Formative Evaluation of the Inquiry Role Approach (IRA) in BSCS Biology

Chairman: Paul G. Koutnik, Midcontinent Regional Education Laboratory, Kansas City, Missouri

Participants:

"Role and Task Dimensions of the IRA Project," Richard M. Bingman, Midcontinent Regional Education Laboratory, Kansas City, Missouri.

"Some Evaluation Model and Design Concerns: The Kansas City Study," John J. Koran, Jr., The University of Texas, Austin, Texas.

"Execution of an Evaluation Project," Jimmy R. Stothart, Northwestern State College of Louisiana, Natchitoches, Louisiana.

"Data Analysis and Interpretation: Louisiana Study," Franklin W. Neff, Institute for Community Studies, Kansas City, Missouri.

Discussants:

Wayne Welch, University of Minnesota, Minneapolis, Minnesota.

Dr. Robert E. Yager, University of Iowa, Iowa City, Iowa.

GENERAL SESSION

Chairman: Michael Fiasca, Portland State College, Portland, Oregon

Speaker: James Tanner, Cleveland Public Schools, Cleveland, Ohio

"Models and Research in Science Education Curriculum Development"

SPECIAL REPORT

Chairman: Paul Westmeyer, Florida State University, Tallahassee, Florida

Presenter: David H. Ost, American Association for the Advancement of Science, Washington, D.C.

"Guidelines for the Education of Secondary School Teachers of Science and Mathematics"

Since the publication of Guidelines for Preparation Programs of Teachers of Secondary School Science and Mathematics in 1961, there have been extensive changes in the science and mathematics curricula at the secondary level. The development of the new materials, along with other changes in the secondary school system have necessitated changes in teacher education programs. Early in 1970 the Commission on Science Education, in cooperation with the National Association of State Directors of Teacher Education and Certification undertook a project to develop new guidelines which give teacher education programs the flexibility and diverseness of experiences contemporary science and mathematics teachers must have. Support for the project was obtained from the National Science Foundation.

After two two-day conferences held in the Spring of 1970 to discuss the needs and problems to which the new guidelines must speak, four committees were established by the project's Advisory Board. The committees, The Philosophy of Science and Mathematics Education, Breadth and Depth of Mathematics Teacher's Preparation in Mathematics and Other Areas, Breadth and Depth of the Science Teacher's Preparation in Science and Mathematics, and Teacher Preparation and Strategies for the Teaching of Science and Mathematics submitted individual reports which were later to become the basis for four chapters in the document. Additional chapters were developed concerning the problems of implementation and the role of a liberal education in teacher preparation.

The new Guidelines represent a departure from the old set in one very important manner. Whereas the 1961 report framed the guidelines in terms of courses and credits, the 1971 document bases its guidelines on performance criteria. Examples of the kinds of performance expected are given whenever possible. A simple model for teacher candidate evaluation is also suggested.

A second departure from the old set of guidelines is in the area of continuing education. The rationale behind the 1971 version reflects the notion that teacher education is a life-long activity. Teacher preparation programs should therefore be built on the concept of career development as a continuing phenomenon. There should be no sharp distinction between pre- and in-service education. The guidelines suggest methods which foster the development of self-evaluation skills. Self-evaluation of performance is essential to any program of self-renewal.

Guidelines for the Education of Secondary School Teachers of Science and Mathematics is the result of many hours of meetings and discussion and the combined effort of over 400 persons. In addition, 16 professional organizations have worked closely with the project and have been involved in the development of the report. As a result of this cooperative effort the document promises to have an affect on teacher education programs for years to come.

Copies of the report may be secured from the Commission on Science Education, the American Association for the Advancement of Science, 1515 Massachusetts Avenue, Northwest, Washington, D.C. 20005.

CONCURRENT SESSION VI

Session VIa - Elementary School Science--Instruction

Chairman: Matthew Bruce, Temple University, Philadelphia, Pennsylvania

1. "Attainment of Conservation of Mass and Weight Using Biologically Oriented Task Materials," Philip White, Queens College, City University of New York, New York, New York.
2. "Activities and Opinions of First Grade Teachers Using Audio-Tutorial Programmed Science Instruction," Howard R. Poole, Jr., Purdue University, Lafayette, Indiana.
3. "Utilizing the TIP Profile in the Evaluation of Science Textbooks," Gerard O. Solomon, West Virginia University, Morgantown, West Virginia.
4. "The Application of Cognitive Dissonance to Children's Acquisition of Piaget's Conservation of Mass," Sherman L. McClure, Mt. Hood Community College, Gresham, Oregon.
5. "The Development of Inquiry Through the Use of Television," Minaruth Galey, Temple University, Philadelphia, Pennsylvania.
6. "The Relative Effectiveness of Two Methods of Instruction in Teaching the Classificational Concepts of Physical and Chemical Change to Elementary School Children--A Replication Study," Alan M. Voelker, University of Wisconsin, Madison, Wisconsin.

ATTAINMENT OF CONSERVATION OF MASS AND WEIGHT USING BIOLOGICALLY ORIENTED TASK MATERIALS

Philip White
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Commack, New York

Piaget suggests attainment of conservation of mass precedes the attainment of conservation of weight. Tests used to determine conservation of these quantities have relied on physical deformation or rearrangement of the task material. One purpose of this study was to design a task in which the change of appearance was the result of biological growth and development. A second purpose was to present the experimental tasks to a population and compare the ages and order of attainment of conservation using these materials with ages and order of attainment using the classical plasticine ball materials. Both experimental and plasticine ball materials were presented to the same population.

The specific hypotheses were: (1) In a conservation task involving biologically-oriented material, children will manifest the attainment of conservation of mass before the attainment of conservation of weight, as in a physically-oriented task. (2) In a conservation task involving biologically-oriented material, children will manifest the attainment of conservation of mass and weight at a greater age than on a physically-oriented task.

The investigator designed tasks using chicken eggs and photographic reproductions of the fertilized yolk and late stages of embryonic development. These materials were used as a stimulus for eliciting conservation responses for the quantities of mass and weight.

Two hundred fifty-six Ss were tested individually, in a counter-balanced order. On each material, attainment of conservation of mass was tested before attainment of conservation of weight. Each subject was asked three questions which required him to: 1) predict changes in the quantity as a result of the deformation (change in appearance), 2) judge if changes of quantity occurred as a result of the deformation,and 3) explain the reason(s) for his judgment. Criteria for the judgment of responses were established by the investigator. A score of 3 was required for attaining conservation for each quantity on both materials.

Frequency distributions, graphs showing the percent of conservers on each quantity and material for every grade level and the McNemar X^2 Test were used to analyze the results.

The hypothesis that children attain conservation of mass before weight was not confirmed on either the plasticine ball or experimental materials. Frequency distributions of the experimental tasks were in the predicted direction in seven of the eight age cells. Also, the number of conservers increased with age on all tasks.

The second hypothesis, that children would attain conservation of mass and weight with the biological materials at a later age than with the physical plasticine materials, was supported by the data. The experimental tasks may be a higher level of complexity and may be outside the ordinary range of experiences of the subjects. The fact that a small number of subjects were able to conserve mass and weight on both Piagetian and the investigator's tasks suggests that the latter materials could be used as a measure of children's ability to conserve conceptually at more complex levels.

ACTIVITIES AND OPINIONS OF FIRST GRADE TEACHERS USING AUDIO-TUTORIAL PROGRAMMED SCIENCE INSTRUCTION

Howard R. Poole, Jr.
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A field study was undertaken to determine the effectiveness of the audio-tutorial form of programed science instruction. The study took place during the 1969-70 school year in 65 classrooms located in 22 school corporations in 11 counties of northwest Indiana. The classrooms were selected by the administraters of each school corporation and were felt to be representative of the first grade classrooms in the study area.

The study consisted of three experimental groups; 25 classrooms of audio-tutorial (AT) science instruction, 26 classrooms of contemporary (CONTROL) science instruction, and 14 classrooms of Science—A Process Approach (AAAS) science instruction. The three experimental groups were compared on 13 lessons of science instruction reported by the teachers through evaluation forms mailed to the Elementary Science Projects in self-addressed and pre-paid envelopes. The evaluation forms contained two types of questions, for specific quantitative data and for opinion information about the science activities of the class.

The teachers of the audio-tutorial form of science instruction spent less preparation time, less teaching time, more additional science teaching time and less average time per week teaching science than did the teachers of the other two forms of science instruction studied. The average AT first grade teacher spent 16 minutes preparing to teach, had students listen to an average of 17 minutes of taped science instruction and spent nearly 30 minutes on additional science instruction per lesson. The average weekly time expenditure of an AT teacher was 36 minutes. The audio-tutorial teachers used each AT lesson an average of 5 days, but varied widely between two days and 10 days. About 20 per cent of the students using AT instruction repeated a taped lesson. The repeating of lessons varied widely between classes. Some teachers had 70 per cent repeating and some had only 1 per cent repeating.

In the opinion of the audio-tutorial teachers, fewer students needed help with the AT science instruction. The teachers also reported average interest in more science instruction and above average interest in repeating the AT lessons by their students. They also reported slightly more than one student per class had problems understanding the taped lesson, and rated the AT form of science instruction as having more of the materials and equipment available to teach a science lesson. In the opinion of the AT teachers the AT form of science instruction was also more useful in helping the teachers understand science than the other forms of science instruction studied.

UTILIZING THE TIP PROFILE IN THE EVALUATION OF SCIENCE TEXTBOOKS

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Traditionally, textbook evaluators have concerned themselves with multiple and diverse criteria. The purpose of this study is to analyze science textbooks solely along the concrete-abstract dimension in order to establish the appropriateness of these texts for student populations differing as to their cognitive maturity along this particular continuum. This study utilized the taxonomy of Image Provocation Profile as the means of assessing the developmental levels reflected by the texts. The TIP Profile was originally developed by this investigator as an instrument with which to assess classroom science teaching behavior on a concrete to abstract imagery related continuum.

Four evaluators were trained in TIP categories. Several dozen science textbooks were read in their entirety by these evaluators. A sampling technique was then developed and a correlation run between whole book and sampling methods in order to assess the reliability of the sampling method. Evaluators re-read some previously analyzed materials after several months had elapsed in order to establish a measure of observer reliability. In addition, inter-observer reliability was established by having each of the readers read twelve of the same textbooks.

Among the more significant conclusions were: differences between science texts designed for given grade levels can be indicated by the procedures followed; the data suggest a pronounced rise in the percentage of abstractness at the third to fourth grade level while indicating a general decline in representational material with increasing grade level; subdivisional breakdown of all cognitive levels measured showed a pronounced prediliction for textbook author utilization of visually oriented stimuli.

This study established a method of evaluating science textbooks along the single dimension of concreteness - abstractness. While this single attribute is not alone sufficient to suggest total textbook appropriateness, when used in conjunction with other measures a more scientific evaluation may result. Textbook authors may find the TIP Profile suggests distinct strategies for the writing and sequencing of text content.

THE APPLICATION OF COGNITIVE DISSONANCE TO CHILDREN'S ACQUISITION OF PIAGET'S CONSERVATION OF MASS

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Acquisition of the Piagetian conservation of substance task through perceptual training devices using three motivational levels and two verbal training levels constituted the basic ideas of this experimental study. The data collected were used to determine if factors or interactions were significant in inducing substance conservation.

The Ss ranged in age from 79 to 108 months and were obtained from seven public elementary schools in Oregon. Those Ss selected for the study were randomly assigned to interaction groups. One hundred and twenty-nine Ss completed the four interaction sessions, in which they were seen individually by the investigator for a total time of one hour to one hour and ten minutes in five school days.

The first and fourth interaction sessions were the pre- and posttests. The second interaction session was symbol training in the expressions, "less than," "more than," and "equal to." The third interaction session (perceptual training) involved four sets of plastic holders and dowel stock classified according to length and diameter with the fourth set corresponding to Piaget's Grouping VII, the logical operation of multiplication of length and breadth. This last classification was never specifically stated as such, but objects were classified by unequal length and unequal diameter with diameter decreasing and length increasing.

The motivational levels associated with the perceptual training were Festinger's Cognitive Dissonance, reward-nonreward, and noncognitive dissonance where no reward was initially offered.

The verbal training levels consisted of Ss being questioned and given the classifications of the perceptual training devices if they were unable to do this. Those Ss assigned to the nonverbal level did not receive this instruction.

The posttest situation differed from the pretest by requiring the Ss to "pick out the sign (symbol) that tells us about the amount of clay here (and here)" in the two part conservation of substance (identity and equivalance) test.

Preliminary analysis of variance produced no significant age or sex differences between the main factors or interaction groups.

A test of independence was performed with respect to number of Ss giving conservation responses on the pretest (zero) and the number of Ss giving conservation responses on the posttest with results significant beyond the .005 level.

A chi-square analysis of variance, after Wilson, was applied to the identity, equivalence and total frequency scores on the conservation of substance posttest. The cognitive dissonance motivational level was found statistically significant beyond the .10 and .05 levels for the total frequency score and the equivalence frequency scores respectively. Interaction of cognitive dissonance-verbal training was significant beyond the .10 level for the total frequency score and at the .10 level for the equivalence frequency score.

Among the recommendations stemming from this study are:

1. the use of simple perceptual training devices with cognitive dissonance and verbal training to provide nonconservers of substance with activities conductive to the acquisition of conservation of substance.

2. the pretesting of first and second grade children to ascertain the stage of conservation development and plan science activities accordingly.

3. the reevaluation of present training devices on the basis of the child's stage of conservation development.

4. the child should be permitted to make conservation discoveries for himself rather than being given the "correct" answer by the teacher.

THE DEVELOPMENT OF INQUIRY THROUGH THE USE OF TELEVISION

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Although the elementary science curricula developed recently require the development and use of inquiry, relatively few of the large numbers of elementary school teachers have been prepared to utilize inquiry. Television with its capability of communicating with a mass audience can be considered as one means of implementing the new curricula. The problem of this study is:

> How do first grade children taught by inquiry techniques in television lessons and those taught by inquiry techniques in classroom lessons compare in their ability to classify objects?

A series of six science lessons was videotaped with the experimenter as television teacher. These lessons were aimed toward helping the children develop skills of classifying. The videotaped programs were viewed by the children while in the classroom with their teacher. During the television lessons, each child had his own kit of materials which enabled him to participate in activities similar to those in the televised instruction.

A test instrument to measure the skills of classification of the children was developed. Its validity and reliability were determined. The same form of the test instrument was used as the pre- and post-test. The children's scores were analyzed using analysis of covariance.

The treatments were assigned at random to each of five first grade classes in a suburban school with a middle-class, racially integrated population. Two classes viewed the six television lessons. For one of these classes (Class 1), the experimenter conducted the introductory and follow-up activities for each program. The second class (Class 2) viewed the programs with no introductory activities. After the programs, each student could pursue any activity he chose. Class 3 was taught by the experimenter without any televised instruction, but with the same teaching techniques, lesson plans, and materials as Class 1. Class 4 was taught, without any televised instruction, by the classroom teacher. Class 5 served as a control group, continuing on its regular schedule, which included no science instruction.

The experimenter found:

1. Television lessons were as effective as classroom lessons in helping first grade children develop skills of classification.
2. Students' choices of individual activities after the programs were as effective as teacher-designed pre-and post-lesson activities in helping children develop their classifying skills.
3. Students can be motivated by television lessons to continue experimenting of their own volition after the close of the programs.

One major obstacle to the implementation of the new elementary science curricula has apparently been the lack of a means to prepare a large number of the elementary school teachers to use inquiry. Only if inquiry is developed and utilized as required by these new curricula can the effects of the curricula be evaluated.

This study provides evidence of the feasibility of using television for the large scale implementation of these curricula. Teachers can use television lessons with assurance that their students can achieve as much as if the teachers had well-developed techniques of inquiry.

THE RELATIVE EFFECTIVENESS OF TWO METHODS OF INSTRUCTION IN TEACHING THE CLASSIFICATIONAL CONCEPTS OF PHYSICAL AND CHEMICAL CHANGE TO ELEMENTARY SCHOOL CHILDREN--A REPLICATION STUDY

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The purpose of this study was to replicate a study reported at the 1968 NARST meeting.

The problem was to determine the relative effectiveness of two methods of instruction in teaching the classificational concepts of physical and chemical change to elementary school children. Sub-problems consisted of (a) determining whether the maturity of the learner as represented by grade level is a factor contributing to the level of attainment of the concepts and (b) determining what relationship exists between the levels of attainment of the concepts and selected standard measures of achievement.

All students in Grades 4, 5, and 6 in a single elementary school in a large urban community comprised the population. Two of the four classes at each grade level were randomly selected to be the treatment groups and the two treatments were randomly assigned to these two classes; six classes received instruction.

The instructional sequences consisted of five lessons approximately 30 minutes in length, each focused around teacher-directed, demonstration and/or discussion. Lesson No. 1 concentrated on developing a general concept of "change." Lessons No. 2, 3, and 4 focused around observation and discussion of demonstrated examples and non-examples of the concepts and Lesson No. 5 consisted primarily of a review of the previous lessons.

Both treatments were designed to develop the generalization "the ultimate criterion in classifying natural phenomena as examples of physical changes or chemical changes is whether the change results in the formation of a new material." One treatment placed the responsibility for formulation on the learner and the other required the teacher to formulate and state the generalization for the learner.

A random sample of 10 students from each of the six classes was selected to receive the final test. The test consisted of presenting each individual with a series of questions and demonstrated and described phenomena. Evaluation of the success of the instructional sequences was based on the ability of the children to complete four concept attainment tasks:

1. Verbalize the selected concepts.
2. Classify demonstrated and described phenomena as examples of physical or chemical change.

3. Explain why a particular phenomenon had been classified as a physical or chemical change.

4. Recognize the need to ask questions as to whether a new material had been formed when there was no obvious evidence that such had occurred.

Data are to be analyzed by tabulations, ANOVA, Newman-Keuls post hoc comparison of means, and correlations.

Session VIb - Learning, Theory, Questioning and Testing

Chairman: Wayne Taylor, Michigan State University, East Lansing, Michigan

1. "The Effects of Utilizing Simultaneous Audio and Printed Media in Science," William G. Holliday, The University of Calgary, Calgary, Alberta.
2. "The Transfer of Training in Visual Space Perception to Applications in the Study of the Optics and Waves Section of PSSC Physics," Roger D. Lewis, Florida State University, Tallahassee, Florida.
3. "Instructional Efficiency with Three-Dimensional Objects in a Task Requiring Identification Keying Techniques," John E. Lutz, State University of New York, Oswego, New York, and H. Seymour Fowler, The Pennsylvania State University, University Park, Pennsylvania.
4. "Cognitive Levels of Test Items in Commercial Biology Examinations," John R. Pancella, Montgomery County Public Schools, Rockville, Maryland.
5. "A Study of the Development of the Skill of Effective Questioning by Prospective Secondary School Science Teachers," Patricia E. Blosser, The Ohio State University, Columbus, Ohio.
6. "A Cognitive Structure Approach to the Delineation of Value Constructs Possessed by Men of Science and Selected Secondary School Students," Stanley B. Brown and L. Barbara Brown, California State Polytechnic College, San Luis Obispo, California.

THE EFFECTS OF UTILIZING SIMULTANEOUS AUDIO AND PRINTED MEDIA IN SCIENCE

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The purpose of this study was to examine the question: Is there a learning advantage in presenting science verbal information utilizing simultaneous audio and printed media in comparison to utilizing singularly either audio or printed media? Meaningful verbal information was learned and test items requiring mental processes other than recall were utilized. Van Mondrans and Travers, and Severin have recently explored a similar question regarding the subject's ability to recall single-word-stimuli. It has been hypothesized by Duker and experimentally examined and reviewed by Hartman that more learning can occur if a combination of visual and auditory presentation of redundant materials is used. However, more recent research has not supported these contentions.

One-hundred and nine tenth grade biology students were randomly assigned to three subgroups. These subgroups were identifiable by the group-paced delivery technique utilized in the learning session. A variation of the posttest only control group experimental design was used. The printed subgroup read the text. The audio subgroup listened to the text read aloud. The audio-printed subgroup utilized a simultaneous combination of these two delivery techniques. All subjects were administered the same printed retention test. For the present study three hypothetical concepts in biology and a retention test for each were developed. The programed text format used in the learning session allowed the subjects to respond to questions and to obtain feedback regarding their answers.

The subjects received a general orientation and some practice on the day preceding the actual experiment. A pilot program involving thirty-three subjects was administered in a nearby school. Susequently, the ETS ITEM ANALYSIS program was used to analyze the retention test questions and to revise the criterian test.

Analysis of covariance was used to test the probability of significant difference between the appropriate adjusted means. The Verbal Reasoning Test scores of Differential Aptitude Tests served as the covariate scores. Analysis of covariance indicated that there was no learning advantage in presenting the information using a simultaneous combination of audio and printed media. Considering the sample size, the experimental design, and the administrative procedures, there was little likelihood that the differences among the subgroups would be of any consequence.

These findings are consistent with recent research. Van Mondrans and Travers' explanation of similar experimental results were supported by Broadbent's theoretical model of the perceptual system as a single channel system. These investigators contended that the redundant information presented through one of the two media never gained access to the brain. Apparently, the optimal medium depends upon both the information presented and the individual learner. Severin's explanation for no learning advantage can be found in the cue summation theory which states that if more learning is to take place, additional information or cues must be provided by one of the media components.

The results of this study lend credence to the applicability of both Van Mondrans and Travers, and Severin's works. Furthermore, the results raise questions concerning the instructional technique of presenting verbal information simultaneously using audio and printed media under conditions similar to this experiment.

THE TRANSFER OF TRAINING IN VISUAL SPACE PERCEPTION TO APPLICATIONS IN THE STUDY OF THE OPTICS AND WAVES SECTION OF PSSC PHYSICS

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The question this study was designed to answer was - can training in visual space perception alter student achievement in the Optics and Waves section of PSSC Physics as measured by the PSSC Examination? A programed instruction unit in visual space perception developed by Erwin Brinkmann at the University of Michigan in 1963 was administered to an experimental group of PSSC Physics students in their mathematics classes while a control group of PSSC Physics students received instruction in number theory in their mathematics classes. Concurrently both groups received their normal instruction in the Optics and Waves section of PSSC Physics.

The DAT Space Relations Section, Form A, and the alternate form, Form B, were the pretest and posttest respectively for measuring changes in visual space perception due to the programed treatment. The scores on each test for the combined groups were ranked in a single series for statistical analysis.

The two PSSC Physics tests, The Behavior of Light, and Light and Wave Motion, were used as posttests in physics. The scores of each subject on both tests were summed and the scores of both groups were combined and then ranked in a single series as the experimental variable in physics. The DAT Space Relations Section, Form A, and PSSC Physics test, Mass and Matter, were used as pretests and their ranked scores served as covariates in the statistical analysis related to physics achievement.

The ranked scores of the experimental group were compared to those of the control group by a rank analysis of covariance, with the ranked scores on the pretests serving as covariates. The results of the analysis showed that visual space perception ability was significantly increased as measured by the DAT Space Relations Section. Although this aptitude was significantly increased, the study failed to show transfer of learning to alter student achievement in the Optics and Waves section of PSSC Physics.

INSTRUCTIONAL EFFICIENCY WITH THREE-DIMENSIONAL OBJECTS IN A TASK REQUIRING INDENTIFICATION KEYING TECHNIQUES

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and

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The intent of this study was to investigate the communication and problem-solving efficiencies of three instructional strategies with learners classified according to aptitude levels within the framework of Snyder's (1968) prototheory of tutor-learner efficiency. The experimental task was an identification keying problem and required the instructional medium of three-dimensional objects.

Allometric Scores were calculated from common mental ability and achievement test scores for all seventh grade students in three Central Pennsylvania public school systems. A random sample of 120 students was selected from ten aptitude levels defined by Allometric Score ranges (four students from each school for each level). Random assignment was made from each aptitude level to each of the three treatment groups.

The treatment groups were defined by the degree of structure of the instructional strategy presented by audio tape to the learner. The unstructured instructional strategy offered only an overview of the task to the learner; the semi-structured strategy included the overview and an operational rule for the keying task; the structured strategy consisted of the overview and rule plus specific directions for successful completion of the task.

Each subject met individually with the investigator (tutor) during the regularly scheduled school day. Measurements were made of the verbal interaction (communication efficiency) as the tutor-learner dyad completed the learning task.

The results were analyzed by The Pennsylvania State University IBM System/360 computer for differences in efficiencies and efficiency variances between the treatment groups and aptitude levels. Statistically significant differences were found in communication efficiency variance between decile aptitude levels, in communication efficiency between quartile aptitude levels, in the number of learner-initiated transactions between decile aptitude levels, and in the proportion of learner-initiated transactions between decile aptitude levels.

It was found that certain learners could be identified by an Allometric Score, irrespective of the instructional strategy, who were able to complete the task with greater verbal efficiency than the other learners. Identification was also possible for learners who initiated more transactions and who might be closer to the instructional goal of self-contained learning than other learners. Thus, the instructional medium employed was found to effect greater efficiency for learners at different aptitude levels for the identification keying task.

Another finding of the study was that the learners in different quartile aptitude levels had different probabilities of solving the defined task within a given number of tutor-learner verbal interactions; that is, the probability of solving the given problem was different for learners at different aptitude levels with different amounts of tutor-learner verbal interaction.

Some support was found for Snyder's (1968) prototheory of tutor-learner efficiency upon which this study was based. Learners who were more efficient in verbal interaction with the tutor also initiated more of the interaction than did other learners. A trend was suggested by the data that the unstructured strategy was the most verbally efficient, followed by the semi-structured and then the structured instructional strategy.

COGNITIVE LEVELS OF TEST ITEMS IN COMMERCIAL BIOLOGY EXAMINATIONS

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Forty-one tenth grade biology tests from commercial publishers, test bureaus, the the Biological Sciences Curriculum Study (BSCS) were analyzed using the six major levels of Bloom's Taxonomy of Educational Objectives Handbook I: Cognitive Domain. Two research questions were posed. What per cent of test questions found in standardized and commercial tenth grade biology examinations is represented by each of the six levels of the Taxonomy? Do tests of the BSCS contain more items which measure higher cognitive levels than do other standardized or commercially prepared tests?

A total of 2,689 test items were classified with 1,933 questions identified as level 1.00 Knowledge; 408 level 2.00 Comprehension; 309 level 3.00 Application; 37 level 4.00 Analysis; one level 5.00 Synthesis; and one level 6.00 Evaluation. Percentages for each level were 71.88 percent Knowledge; 15.17 percent Comprehension; 11.49 percent Application; 1.37 percent Analysis; 0.04 percent Synthesis; and 0.04 percent Evaluation. Only 39 items or 1.45 percent were above level 3.00.

A panel of twelve distinguished judges, including four contributors to the Taxonomy, was used to validate the investigator's competency in classifying test items. A random, proportional sample of 56 items was prepared for the judges to agree or disagree with the classfication of the sample items (model). The model contained 38 Knowledge items, 8 Comprehension, 6 Application, 2 Analysis, one Synthesis, and one Evaluation. Agreements with the model ranged from a high of 90.4 percent on level 1.00 items to a low of 33.3 percent for the single 5.00 item. The overall agreement was 83.9 percent for all judges for all sample items. When the four higher levels were combined, the agreement was 65.2 percent for the grouping. Greater agreement was realized for levels 1.00 and 2.00 than for upper levels. When items rated higher than the model were included as agreeing with the model, the accumulative agreement with the sample items was raised from an overall 83.9 percent to 92.2 percent.

Each test used in this study was described by percent totals of items in each of the six Taxonomy categories. Very few tests other than BSCS tests reflected more than 10 percent questions above level 2.00. Five tests were totally level 1.00. Eleven tests had level 1.00 items in excess of 90 percent. Only BSCS tests reflected levels above 3.00. The BSCS Process of Science Test (POST) provided a wider utilization of the six cognitive levels of the Taxonomy than any other test studied.

Recommendations include the following:

1. Standardized and commercial tenth grade biology examinations other than the BSCS tests should not be used to measure cognitive levels above 2.00 Comprehension.

2. The POST could be used as a model for teachers who wish to develop tests to measure cognitive processes higher than Knowledge.

3. A future study should be done to compare present examinations with newer ones, to observe whether or not the impact of the recent emphasis on teaching for process, rather than fact recall, is being reflected in the examinations.

A STUDY OF THE DEVELOPMENT OF THE SKILL OF EFFECTIVE QUESTIONING BY PROSPECIVE SECONDARY SCHOOL SCIENCE TEACHERS

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The major problem investigated was to assess the effectiveness of an instructional procedure designed to develop skill in questioning by prospective science teachers. Subproblems investigated were (a) to determine if skill developed during this instructional sequence would transfer to the student teaching experience and (b) to determine possible relationships of selected personality factors to the development of questioning skill.

The study extended over three quarters and involved forty-two pre-service secondary school science teachers. During each quarter the subjects were randomly assigned to one of four groups: R_1, R_2, R_3, R_4. A brief design of the study is:

Group	Pretest	Treatment	Post-test
R_1	Yes	Teachers for instructional procedure	Yes
R_2	Yes	Student-evaluators for R_1	Yes
R_3	Yes	None	Yes
R_4	No	None	Yes

Randomly selected students from each of the four groups were observed during student teaching to determine if the skill gained in the instructional sequence would transfer to the public school classrooms and to determine the effects of time and student teaching on questioning skills. Lessons observed were audiotaped for subsequent analysis.

A panel of three judges analyzed the videotaped post-test lessons for types of questions asked. The investigator analyzed the audiotapes. Additional analyses, of videotapes and audiotapes, were done to identify behaviors emphasized as a part of the instructional sequence. Data obtained from these analyses as well as data obtained through the use of written instruments (Otis Quick-Scoring Mental Ability Test, Myers-Briggs Type Indicator, Educational Set Scale by Siegel and Siegel) were subjected to parametric statistical analyses to test the seven hypotheses of the study.

These hypotheses were:

1. Skill in questioning as a teaching technique cannot be developed through practice and experiences involved in an instructional sequence.

2. There is no effect of treatment (teacher of a microclass, pupil in a microclass, member of a control group) on questioning behavior.

3. The skill developed during the instructional sequence will not transfer to the student teaching experience in the public schools.

4. There is no relationship between intelligence and questioning behavior.

5. There is no relationship between sex and questioning behavior.

6. There is no relationship between educational set and questioning behavior.

7. There is no relationship between personality type and questioning behavior.

Three criterion variables were chosen to test the hypotheses. These were:

1. asking Open Question (those having a wide range of acceptable responses),

2. pausing to allow students time to think before responding,

3. questioning in a manner designed to decrease the percentage of teacher talk during a lesson.

The .10 level of significance was used for rejection of each hypothesis with respect to each of these criterion variables.

Hypotheses one and two were rejected for the criterion variables of pausing and of decreasing the percentage of teacher talk but not for the variable of asking Open Questions. Hypotheses three through seven could not be rejected for any of the criterion variables.

Questioning appeared to be a skill that could be developed, through instruction and practice, by the individuals involved in the study. The development of questioning skill did not appear to be limited by intelligence, sex, personality type, or educational set in so far as this sample was concerned.

A COGNITIVE STRUCTURE APPROACH TO THE DELINEATION OF VALUE CONSTRUCTS POSSESSED BY MEN OF SCIENCE AND SELECTED SECONDARY SCHOOL STUDENTS

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and
L. Barbara Brown
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The primary purpose of this study is to present a method for delineating an individual's conceptual structure. Specifically, the methodology is designed to tap into the implication chain by which an individual structures and interprets the world about him. Each person's repertoire of value constructs is an attempt to create order in his own phenomenal field, and is his system of codifying his experience.

The hierarchic technique utilized in this study allows each subject to delineate and map a protocol of some of his most important commitments in his present life. In rank ordering these commitments in terms of a scale of values, or overarching principles of choice, the subject expresses his own personal value structure and life style.

Constructs which function at upper levels of superordination are of fundamental importance. An awareness of them allows maximization of our own and others' understandings of, and capacities to predict, future behavior and events and to avoid net implicative loss. This research methodology provides instruments to maximize the subject's freedom to express himself, formalizes the contribution, and yields quantifiable data.

The study focuses on the hierarchial nature of construct networks in establishing value patterns possessed by an individual. It is assumed that superordinate constructs (those which include another as one of the elements in its context) carry a greater number of implications than subordinate constructs (those which are included as an element in the context of another). There should be a higher level of resistance to change on superordinate constructs since a change at this level would necessarily involve a great number of related changes together with a considerable risk of the development of inferential incompatibility within the system. It is suggested that the scientist's relative resistance to change of certain superordinate constructs and related subordinate constructs will be an indicator of his important values.

This research is concerned with the scientist's and selected secondary level student's relative resistance to change of personal values in a hierarchic context from the viewpoint of a theory of construct implications.

Three methodologies will be utilized:

1. a hierarchic method for eliciting superordinate (value) constructs;
2. a relative resistance to change grid form, which will operationally define the dependent variable of resistance to change;

3. an implication grid form which will present in systematic form the implicative network that relates an individual's set of constructs in a given hierarchic context.

One significant outgrowth of the implication grid method used in this research in progress involves the independent modification of superordinate or subordinate implications of any given construct dimension, i.e., the tightening or loosening. For example, change in the subordinate implications may be facilitated if the superordinate implications are temporarily stabilized. If the superordinate implications are to be modified, it may be strategic in the educational setting to keep the subordinate implications relatively stable.

That constructional reorganization or psychotherapeutic change can proceed only from a position of relative stability is implicitly recognized in many teaching situations or other interpersonal strategies. This takes the form of an attack on a specific student contribution with the preface that the student is "doing well in general," or has a "good grasp of the subject," "however, on topic A..." and so on. In this case, the teacher is validating the student's superordinate constructions in order to minimize the trauma of attack on the subordinate aspect of construing.

The implication grid approach can be useful in mapping the student's scientific value protocol and in charting the relative stability of both his superordinate and subordinate implications.

Session VIc - Symposium----------What Science is Relevant?

Chairman: Richard E. Haney, University of Wisconsin-Milwaukee, Milwaukee, Wisconsin

Presentations:

"Introduction to the Problem of Relevance," Richard E. Haney, University of Wisconsin-Milwaukee, Milwaukee, Wisconsin.

"What Science is Relevant for Children of the Central City," Joseph C. Paige, Federal City College, Washington, D.C.

"What Science is Relevant for Elementary School Children," Donald B. Neuman, University of Wisconsin-Milwaukee, Milwaukee, Wisconsin.

"The Relevance of Science Teaching as Viewed by a State Science Supervisor," Kenneth Dowling, Wisconsin State Department of Public Instruction, Madison, Wisconsin.

"Preparing Teachers to be Relevant," Lawrence Lowery, University of California, Berkeley, California.

Session VId - Symposium--------Interrelationships of Piagetian Research, Humanistic Psychology, Discovery Learning, and Creativity in Developing a Theory of Instruction in Science Education

Chairman: Leslie W. Trowbridge, University of Northern Colorado, Greeley, Colorado

Participants:

1. Piagetian research: Robert B. Sund, University of Northern Colorado, Greeley, Colorado.
2. Self-evaluation: Clifford Hofwolt, Minot State College, Minot, North Dakota.
3. Creativity and talents: Alan McCormack, University of British Columbia, Vancouver, British Columbia.
4. Inquiry and discovery teaching: Leslie Trowbridge, University of Northern Colorado, Greeley, Colorado.
5. Humanism in science: Roger Bybee, University of Northern Colorado, Greeley, Colorado.

Session VIe - Symposium----------Behaviors of Beginning Science Teachers

Chairman: James Albright, Syracuse University, Syracuse, New York

Presentations:

"Intentions, Self Perceptions, Role Perceptions and Classroom Verbal Behavior of Science Student Teachers," John Schaff, Syracuse University, Syracuse, New York.

"Intentions, Self Perceptions, Role Perceptions and Classroom Verbal Behavior of First Year Science Teachers," Francis P. Collea, Fullerton State College, Fullerton, California.

"Patterns of Classroom Verbal Behavior of First Year Science Teachers," William DeLucia, Syracuse University and East Syracuse-Minoa Central Schools, East Syracuse, New York.

"System Conflicts and the Beginning Science Teacher," Robert Daley, Jamesville-DeWitt High School, DeWitt, New York.

JOINT SESSION NARST-AETS

Evolution in Science Education Curriculum Reform

Chairman: Frank X. Sutman, Temple University, Philadelphia, Pennsylvania

Speakers: "Science Curriculum Reform in the United States and Abroad," Stephen Winter, University of Buffalo, Buffalo, New York.

"Developments in Health Science Education," William Stickley, Case-Western Reserve University, Cleveland, Ohio, and T. Joseph Sheeham, University of Connecticut, Farmington, Connecticut.

REPRESENTATION OF EARTH SCIENCE PRINCIPLES IN CURRENT JUNIOR HIGH SCIENCE TEXTS

Kenneth T. Henson
Indiana State University
Terre Haute, Indiana

Previous studies indicate that teaching science via principles is a meaningful method. As early as 1927, several studies had given evidence which supports this claim. Later, both the National Society for the Study of Education and the Progressive Education Association testified affirmatively to this postulate.

The purpose of this study is to determine the extent to which textbooks currently adopted for use in junior high schools represent those principles found pertinent to understanding the earth sciences.

The twenty-five texts selected for this study represent most of the junior high science texts currently adopted by schools throughout the country. The principles on which the study was based are taken from a recent study which reported 108 principles pertinent to understanding five areas of earth science.

Six judges were selected and instructed to:

1. Read each text to develop familiarity,
2. Study the list of principles,
3. Carefully analyze each text at one grade level, and
4. Indicate each time a principle is actually stated in the literature.

To determine the degree of agreeability among judges, each text was analyzed by two independent judges. Criteria for acceptance of the responses were that (1) if both judges noted that a principle was represented in a particular text, that that text would be credited for presenting the principle clearly, (2) if only one of the two judges evaluating a text indicated that a certain principle was represented, that text would be noted for presenting the principle, yet not in a clear manner, and (3) if neither judge indicated that a particular principle was represented in a certain text, that that text would be noted for not having presented that principle.

Mean principle representation varied from text to text over a range of 61.1 percent. The six complete sets of texts involved in the study represent a similar degree of representation of all principles; however, the variance within each area ranges up to 4 to 1. The higher the grade level; the greater the number of principles represented.

None of the 25 texts affords adequate representation to principles in all areas of science. Some texts do not represent an adequate number of principles in either area.

Although the degree of representation varies greatly from text to text, the high consistency of degree of principle representation among the sets of texts indicates that the development of these tests did consider principle representation. High variance among earth science areas indicates disagreement as to the importance of each area relative to other areas.

This study shows that although science educators realize that science principles are important to the process of understanding science, they do not agree as to (1) which principles are most important and (2) which grade level is most appropriate for each area of earth science. It suggests that studies are needed to identify principles pertinent to understanding each area of earth science and to determine the most appropriate grade level for placing each area of earth science.